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Analysis of factors that affect responding in a two-response chain in children with developmental disabilities

Stephanie Ann Contrucci Kuhn

Louisiana State University and Agricultural and Mechanical College, scontru@lsu.edu

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ANALYSIS OF FACTORS THAT AFFECT RESPONDING IN A TWO-RESPONSE
CHAIN IN CHILDREN WITH DEVELOPMENTAL DISABILITIES

A Dissertation
Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
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requirements for the degree of
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In

The Department of Psychology

Stephanie Ann Contrucci Kuhn
B.S., Virginia Polytechnic Institute and State University, 1993
M. A., Louisiana State University and Agricultural and Mechanical College, 2000
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ABSTRACT

Behaviors that are appropriate, inappropriate, or a combination of both can be linked together in a behavior chain. When the contingencies for one response change (e.g., reinforcement is withheld for the last response in the chain; the last response is reinforced even if it occurs without the other responses in the chain) or the environmental conditions change (e.g., access to the reinforcer is available independent of responding), the other responses in the chain may be affected. Little is known about these types of effects on behavior chains. Several operant processes may disrupt behavior chains. The purpose of this study was to examine the effect of three relevant procedures (i.e., extinction, noncontingent access to reinforcement, and "unchaining") on behaviors that occur as part of a behavior chain. Results indicated that all three procedures resulted in a change in responding from baseline. Overall, extinction and satiation resulted in a decrease in both responses in the chain, although this effect was less clear with satiation. In addition, during the unchaining procedure, decreases were observed in the first response in the chain but not in the second response.

INTRODUCTION

Much of human behavior consists of discrete responses that occur in behavior chains. A behavior chain is a sequence of behaviors that are functionally linked to the same reinforcer. Examples of behavior chains can be found in most everyday activities. Brushing teeth, driving an automobile, and making a sandwich are examples of everyday behavior chains that are made up of individual discrete behaviors (e.g., picking up the toothbrush, taking the cap off of the toothpaste, etc.). These behaviors occur in such a fluid fashion that they are rarely thought of as separate behaviors. The fact that they are in fact discrete behaviors is important to consider in both the acquisition and elimination of behavior.

In individuals with developmental disabilities, learning even simple skills (e.g., purchasing an item from a vending machine) can require extensive training. Many of the skills necessary for independent functioning among individuals with substantial disabilities are response chains. As such, a large portion of the research on skill acquisition with this population has focused on "chaining". This is accomplished by breaking complex tasks into smaller, more teachable units (i.e., the "links" in the chain). The individual components of the chain are then taught using prompting and reinforcement and are linked together so that the sequence of behaviors operate as a functional unit. For example, two students with severe handicaps were taught laundry skills (e.g., use of a commercial washing machine) using forward chaining (McDonnell & McFarland, 1988). The steps involved in operating the machine were listed in a task analysis. Initially, students received reinforcement contingent on performing the first step listed in the task analysis (i.e., locating an empty machine). Next, additional

response requirements (i.e., adding soap) were required in order to access reinforcement. Results indicated that the chaining method was an effective way to teach both students to independently perform laundry skills.

Other sorts of behavior chains may be shaped inadvertently by the social environment. Three types of behavior chains can develop in this manner. First, a series of appropriate responses can be linked in a chain. For example, suppose a small child must use a step stool to reach the sink and wash her hands. Initially, a parent may move the stool over to the sink (first step in the chain) and then help the child get up on the stool (second step in the chain). The next time the child tries to wash her hands, the parent may help the child move the step stool, but then the parent may move away to do something else, and the child may climb on the stool by herself. Finally, the child may move the stool over the sink and climb on it without any assistance. In this example, a sequence of behaviors that involved moving a stool and stepping on it were established in a chain.

Second, a series of inappropriate responses can get established as a chain. For example, a child with developmental disabilities and communication deficits may learn to access adult attention by engaging in a chain of inappropriate behaviors. Suppose, for example, that a child throws a toy and receives a reprimand. Then, suppose that the next time the child throws the toy, he receives no reprimands. The child then may throw the toy and hit his sister, and the adult may deliver a reprimand. Next time, the child may again throw a toy and then hit his sister, which would be followed by a reprimand. In this example, a chain involving throwing toys and hitting has been established. Finally, a behavior chain that includes both appropriate and inappropriate behavior can be

established. For example, suppose a child's scream brings his or her mother into the room. Once the mother is in the room, the child smiles at his or her mom and receives a hug. In this example, an inappropriate behavior (i.e., screaming) is established in a chain with an appropriate behavior (i.e., smiling), with attention as reinforcement at the end of the chain. These types of behavior chains have received much less attention in the literature.

Several studies in the applied literature on the treatment of problem behavior have suggested that some failures to reduce problem behavior with functional communication training (FCT) may be due to behavior chains that are inadvertently established during training (Wacker et al., 1990; Fisher, Piazza, Cataldo, Harrell, Jefferson, & Conner, 1993; Winborn, Wacker, Richman, Asmus, & Geier, 2002). Treatment with FCT involves teaching the child to emit an alternative response (e.g., handing a picture card to a therapist) to receive the reinforcer that is functionally related to problem behavior, such as attention or escape from demands. Treatment typically includes an extinction component for problem behavior (i.e., withholding the reinforcer if problem behavior occurs). Prior to FCT training, the child has a history of receiving reinforcement for problem behavior. As described in more detail below, a chain consisting of problem behavior, communication, and reinforcement could be established if problem behavior continues to occur with the introduction of FCT.

Prior to examining the ways these chains can be acquired and modified, it is important to consider the processes involved in behavior chains. A number of important basic processes underlie the acquisition and maintenance of behavior chains. These processes include differential reinforcement, conditioned reinforcement, and establishing

operations. These processes and their relevance to behavior chains are discussed in the next section.

Basic Processes

Differential Reinforcement

Differential reinforcement involves two procedures that are relevant to establishing and maintaining responses in behavior chains. First, differential reinforcement involves selectively reinforcing certain behaviors and not others. When teaching behavior chains, correct responses are reinforced, and incorrect ones are not. Under this condition, correct responses should increase and incorrect responses should decrease. Second, differential reinforcement involves reinforcing a behavior in the presence of certain stimuli, but not others. So, when teaching behavior chains, a response is only reinforced if it follows the previous response.

In this manner, the performance of each link in a chain will produce a stimulus condition that signals the availability of reinforcement contingent on performance of the next behavior in the chain. That is, each link will serve as a discriminative stimulus (S^D) for the next response. According to Michael (1993), a stimulus is an S^D if it meets the following three conditions: (a) the stimulus has a history of correlation with the differential availability of an effective form of reinforcement given a particular type of behavior, (b) the stimulus alters the momentary frequency of a type of behavior because in the presence of that stimulus the relation between the behavior and the consequence has been different than in the absence of that stimulus, and (c) in the absence of the stimulus, the unavailable event would be effective as reinforcement if it were obtained. As a result of the differential reinforcement used to establish behavior chains, each

response in the chain will set the occasion for the next response, and each response is unlikely to occur in the absence of the previous response. The functional significance of a stimulus in a chain serving as an S^D for the next response is that any given behavior in the chain must occur at a specific point in the chain or the remainder of the chain may be disrupted.

Conditioned Reinforcers

Unconditioned reinforcers are stimuli that increase behaviors that they follow even if the individual has had no previous experience with the stimuli. Examples of unconditioned reinforcers include food, water, sexual contact, and sleep. Conditioned reinforcers also increase behaviors that they follow, but this effect occurs due to an association with other reinforcers. For example, money put into a vending machine could become a conditioned reinforcer because it is paired with the delivery of food. Conditioned reinforcers help bridge the time gap between a response and primary reinforcement.

In the previous section, the stimulus change that occurs after each response in a behavior chain was described as an S^D that signals the availability of reinforcement contingent on performance of the next response in the chain. Because it is associated with the reinforcer at the end of the chain, each stimulus change also functions as a conditioned reinforcer for the previous response (Williams, 1994). That is, each stimulus change maintains the preceding behavior (conditioned reinforcer) and sets the occasion for the next response (S^D). Basic research findings indicate that the strength of conditioned reinforcers depend on the number of pairings the conditioned reinforcer has had with primary reinforcers, the schedule of primary reinforcement in the presence of

the conditioned reinforcer, and the temporal interval between the onset of the conditioned reinforcer and the primary reinforcers.

Establishing Operations

An establishing operation is an environmental event, operation, or stimulus condition that momentarily alters the reinforcing effectiveness of other events and the frequency of behavior that had been consequated by those events (Michael, 1993). In behavior chains, events that increase the effectiveness of the terminal reinforcer should increase the likelihood that the entire behavior chain will occur. These same establishing operations also should increase the effectiveness of the conditioned reinforcers in the chain.

Michael (1987) divided types of establishing operations into two main groups: unconditioned establishing operations (UEO's) and conditioned establishing operations (CEO's). UEO's "are events, operations, (or) stimulus conditions whose value-altering effects are unlearned. They depend on the evolutionary history of the particular species, and vary from species to species" (p.30). For example, after falling down and skinning a knee, an individual may immediately press his or her hands hard against the knee. Pressing on a wound decreases the pain. We are born with pain cessation as a reinforcer, and we learn to press on wounds to decrease the pain. The pain establishes pain attenuation as a reinforcer. CEO's are value-altering effects that have been learned. For example, suppose a gym teacher works kids very hard, and they get extremely thirsty while in the gym. After the gym has been paired with exercise, the kids may feel thirsty whenever they are in the gym. Being in the gym increases the reinforcing effectiveness of water. Recently, the division of establishing operations into these two categories has

received more attention in the literature (e.g., Duker, Kraaykamp, & Visser, 1994; Hall & Sundberg, 1987; McGill, 1999; Sigafoos, Reichle, Doss, Hall, & Pettit, 1990; Wilder & Carr, 1998). Yet, very few applied studies have focused on this distinction while manipulating establishing operations during assessment and treatment procedures.

Establishing operations are sometimes incorrectly identified as discriminative stimuli and vice versa. Michael (1993) discussed several key distinctions between the two. First, discriminative stimuli are related to the differential availability of reinforcement for a certain behavior. Establishing operations are related to the differential reinforcing effectiveness of consequences, such as reinforcement. Michael (1993) uses the example of escape from painful stimulation to emphasize these differences. For a discriminative stimulus, an effective consequence must have followed the response in the presence of the stimulus, and the response must have occurred without the consequence in the absence of the stimulus. In the absence of shock, painful stimulation (the relevant establishing operation) is not present; therefore, the termination of painful stimulation is not reinforcement. In this example, painful stimulation is an establishing operation, not a discriminative stimulus.

This can also be demonstrated in a classroom example. Suppose a child has a regular classroom teacher and a student teacher. The student teacher allows escape from demands for noncompliance. The regular classroom teacher does not allow escape from demands for noncompliance. As a result, it is likely that the student teacher will be established as an S^D for negative reinforcement and the regular teacher will be established as an S-Delta (i.e., a stimulus that signals the absence of reinforcement). The child finds demands aversive and engages in noncompliance to get out of demands when the student

teacher is teaching. The student teacher is an S^D for noncompliance, and the demands are an establishing operation. There have been numerous studies addressing the effects of establishing operations on behavior over the past twenty years (see McGill, 1999, and Smith & Iwata, 1997, Wilder & Carr, 1998 for a review).

The concepts discussed thus far (establishing operations, differential reinforcement, and conditioned reinforcement) are the processes and procedures involved in chaining. Next, it is important to review how chains are established and eliminated in more detail.

Response Chains

Establishing Response Chains

"Chaining" is the process used to teach each component of the chain and then to link them together such that each response produces the S^D for the next response and the conditioned reinforcer for the previous response. There are three common ways to teach chains: forward, backward, and total task chaining. In backward chaining, training begins with the last response in the chain. The previous responses in the chain are taught one at a time in reverse order, as each component is mastered. For example, Hagopian, Farrell, and Amari (1996) treated the liquid refusal of a 12-year-old boy with autism and mental retardation using backward chaining and fading. The steps trained were: (a) bringing a cup of water to mouth, (b) accepting water into mouth, and (c) swallowing. At first, reinforcement was provided for swallowing (without water). After success with swallowing, reinforcement was then provided contingent on swallowing water that was placed in his mouth with a syringe, and so on until all steps were mastered. The main advantage of backward chaining is that the terminal reinforcer follows the final response

in the chain on every learning trial, which may lead to a stronger chain (Cooper, 1987; Kazdin, 2001; Williams, 1994).

With forward chaining, training begins by teaching the first response in the chain. Subsequent responses are gradually added to the chain in order, with reinforcement always delivered after the last response that is taught. For example, a 9-step chain for a side-of-the-foot soccer pass was taught to three mentally retarded adults using forward chaining (Luyben, Funk, Morgan, Clark, & Delulio, 1986). The participants were initially required to complete the first component in the chain (place the toe directly in front of the ball) to receive reinforcement. Each subsequent response (e.g., look at the ball, step forward with the nonkicking foot) was added to the requirement for reinforcement as the previous component in the chain was mastered. All participants mastered the response chain. An advantage of forward chaining is that the responses are always practiced in the order in which they will be executed (Cooper, 1987).

Finally, the total task method requires that each response in the chain is taught during every session, and assistance is provided where necessary until all steps are mastered. An advantage of the total task method is that the entire chain is practiced during every training session. This method also is conducive to training in actual environments where the entire task must be performed (Cooper, 1987; Spooner, 1984). One disadvantage of the total task method is that the participant is taught multiple novel skills simultaneously. McDonnell and McFarland (1988) compared forward and total task training strategies while teaching laundry skills to students with disabilities. The steps taught included locating an empty machine, adding soap, loading clothes, setting the wash cycle, inserting quarters, and starting the machine. The total task training procedure

required the students to complete all of the steps of the chain. Error correction was provided when necessary, and praise was delivered for independent performance. Results indicated that the total chaining strategy was more efficient than forward chaining in producing acquisition.

Once established, behavior chains can appear as one fluid behavior (e.g., shifting gears in car). However, changes in environmental contingencies can disrupt established behavior chains. These disruptions can occur at different points within the chain, as discussed in the next section.

Breaking Behavior Chains

Michael (2000) described a simple behavior chain and procedures that might disrupt the chain. In this chain, the first response (R1) turns on an auditory stimulus (a tone). In the presence of the tone, a second response (R2) results in delivery of food (reinforcer) and termination of the tone. The tone, because of its relation to food, functions as conditioned reinforcement for R1 and as an S^D for R2.

Michael described two procedures that directly target R2 but that also should alter R1. One such procedure is to allow free access to large amounts of food prior to sessions (i.e., satiation), which would likely decrease the effectiveness of food as reinforcement. R2 would decrease because of the functional relationship between the response and food reinforcement. R1 also may decrease because the effectiveness of the tone as a conditioned reinforcer in the chain depends on its association with food. That is, the tone was established as reinforcing due to its association with food, and processes that alter the effectiveness of the primary reinforcer also may alter the effectiveness of the conditioned reinforcer. Another procedure that might alter both R1 and R2 would be to

withhold food reinforcement for (i.e., extinguish) R2. R2 would decrease because the response reinforcer relation would be broken. R1 also may decrease because the tone would no longer be paired with food. Finally, Michael described a third procedure that would disrupt R1 but not R2. Under this procedure, R2 would continue to produce food when the tone was present, but R2 would also produce food just as often when the tone was absent. Thus, R1 would decrease because the tone, no longer differentially paired with food, would function as neither a conditioned reinforcer nor an S^D .

Basic studies have led to a greater understanding of how behavior chains operate and how responding in the initial and terminal links of a chain are affected by various procedures, such as satiation (e.g., Ferster & Skinner, 1957; Fischer & Fantino, 1968; Nevin, Mandell, & Yarensky, 1981), extinction (e.g., Caitlin & Gleitman, 1973; Fantino, 1965; Mandell, 1980), and punishment (e.g., Leslie, 1969; Mandell, 1980; Mansfield & Rachlin, 1970; Nevin et al., 1981). Most basic studies have examined responding under chain schedules rather than behavior chains. With chain schedules, two or more simple reinforcement schedules are presented sequentially, and each schedule is associated with a distinct stimulus. Responding under each schedule leads to the next schedule, and responding under the terminal schedule leads to the primary reinforcer.

The discriminative stimulus that is presented when the schedule changes eventually will function as a conditioned reinforcer for responding under the previous schedule (Mazur, 1992). The arrangement in a chain schedule varies by study, but an example of a common arrangement can be found in Fischer and Fantino (1968). In this study, two response keys were present in the experimental chamber. At the beginning of a session, the left response key was lit by a green light and the right key was dark.

Responses on the left key (initial link in chain) were reinforced on a variable interval (VI) 45-s schedule by the illumination of the right key by a red light. When the right key was lit, the left key was dark. Responses on the right key (terminal link in chain) were reinforced on a VI 45-s schedule by the presentation of food. After reinforcement, the left key was illuminated and the right key was dark.

Both chain schedules and behavior chains involve a sequence of responses that are functionally linked to the same terminal reinforcer. Although most basic studies on chain schedules have required more than one response in each link of the chain, an arrangement where one response is required in each link can also be considered a chain schedule. A simple response chain such as the one described by Michael (2000) where one response results in a tone sounding and a second response results in food reinforcement is similar to a chain schedule under which one response is required for reinforcement in each schedule of the chain (i.e., a continuous schedule). Therefore, the results of basic studies on chain schedules can provide information about how procedures such as extinction, satiation, and others affect responding in a behavior chain. In the following sections, these procedures and results of basic findings are discussed in more detail.

Satiation. Satiation refers to the continued presentation or availability of a reinforcer that reduces its effectiveness (Catania, 1998). Satiation, which is classified as an establishing operation, may occur as responses are repeatedly reinforced or it may be arranged independent of responses (i.e., noncontingently). A commonly used procedure to study the effects of satiation with food reinforcers is prefeeding (presenting food for some fixed time or at some fixed amount before the session) (Catania, 1998). Satiation

effects are temporary and are especially evident with primary reinforcers such as food, water, and sexual stimulation (Kazdin, 2001). Conditioned reinforcers, such as praise or tokens, maintain responding due to their association with primary reinforcers. As such, it would be expected that a conditioned reinforcer would also be less effective if the associated primary reinforcer were ineffective due to satiation. Responding to access those conditioned reinforcers would be expected to decrease along with responding to access primary reinforcers. Thus, in a behavior chain where all of the responses in a chain are linked together by their association with the terminal primary reinforcement, all responses in the chain may decrease.

Fischer and Fantino (1968) studied the effects of satiation on responding in pigeons in a two-component chain schedule (as described above) using two different satiation procedures. During one phase of the study, the satiation procedure involved repeated exposure to reinforcement over a large number of sessions. During initial sessions, responding decreased in the initial link of the chain schedule while responding maintained in the terminal link. However, in later sessions, response rates in both links declined simultaneously. Next, the pigeons were prefed the amount of grain sufficient to increase their body weight to equal their body weight following the satiation sessions described above. Initially during this phase, responding decreased in the initial link while responding maintained in the terminal link. However, following approximately four prefeeding satiation sessions, responding began to decrease simultaneously in both links. So, both satiation procedures eventually resulted in a simultaneous decrease in responding during both links of the chain.

Extinction. Extinction is a procedure in which reinforcement for a behavior is discontinued (see Lerman & Iwata, 1996, for a review of research on extinction). The decrease in responding observed during extinction is part of the process generated by reinforcement (Catania, 1998). There are two procedural variations of extinction: (a) no reinforcers are delivered, or (b) reinforcers are delivered, but there is no contingency between the response and the reinforcer. Both procedures result in a decrease in behavior previously associated with reinforcement.

Extinction in a behavior chain can happen in two ways. First, the terminal reinforcer can be withheld. Second, a conditioned reinforcer earlier in the chain can be withheld. In this case, a particular response in the chain would no longer produce the stimulus condition that functions as an S^D and a conditioned reinforcer. When a chain is broken in the middle, the responses before the break will extinguish, but behaviors following the break will not undergo extinction (Findley, 1962; Fry, 1962; Kelleher & Thomas, 1964; Mazur, 2002). The variation that is the most relevant here (i.e., as described by Michael, 2000) is the procedure where the terminal reinforcer is withheld. All of the studies described below used this variation of extinction to examine the effects on the links of a behavior chain.

The effects of extinction on responding in chains have been studied infrequently and procedures have varied. Therefore, it is difficult to draw an overall conclusion about the effects of extinction on behavior chains. Because the responses in the early part of a chain are further from the terminal reinforcer, they are expected to be more readily disrupted due to the temporal delay between the response and the reinforcer (Mazur, 2002). The majority of studies examining the effects of extinction on chain

schedules found that responding in the first link of a chain schedule decreased more rapidly and to a greater degree than responding in the second link (Catlin & Gleitman, 1973; Fischer & Fantino, 1967; Mansfield & Rachlin, 1970). For example, Catlin and Gleitman (1973) implemented extinction with a FR 7-FR 7 chain schedule by withholding reinforcement following the terminal response. During extinction, disruption was greater in the first component than in the second component of the chain.

However, some researchers have hypothesized that earlier behaviors in the chain should persist longer than behaviors closest to the terminal reinforcer due to a conditioned reinforcement effect. For example, Fantino (1965) trained pigeons to respond on concurrent chain variable interval (VI)- fixed ratio (FR) schedules and then implemented extinction (i.e., withheld primary reinforcement at the end of the chain). The results indicated that responding in the initial link of the chain continued after responding stopped in the terminal link. Fantino hypothesized that the stimuli correlated with the terminal links acted as conditioned reinforcers for responding in the initial link but that they no longer acted as discriminative stimuli for responding in the terminal link. Fischer (1967) found that with less training (i.e., massed training with shorter reinforcement periods), early links in the chain extinguished more quickly, whereas with more training (i.e., distributed training with longer reinforcement periods), later links in the chain extinguished more quickly.

Finally, Mansfield & Rachlin (1970) examined the effects of extinction, satiation, and punishment on two-link response chains. In this study, a peck on the right key not followed by a peck on the left key within 10 s was defined as an abortive sequence. Any additional responses following an abortive sequence (i.e., response on

initial link and no response on terminal link) would require that the pigeons respond on the initial link again before responses on the terminal link key would be reinforced. Results indicated that responding declined simultaneously in both links and that the proportion of aborted to completed responses was fairly constant across all procedures.

The disparities in studies examining extinction in behavior chains have not been resolved. More research is necessary to identify factors that affect responding in the different links of the chain when the primary reinforcer is withheld.

Unchaining. As described earlier, a behavior chain is established via differential reinforcement. That is, reinforcement is delivered when R2 is preceded by R1 (and the stimulus condition that it produces) and is withheld when R2 occurs in the absence of R1. For the third procedure described by Michael (2000) (which he did not name, but we will call "unchaining"), R2 would continue to produce food when the tone was present, but it would also produce food just as often in the absence of the tone. In the unchaining procedure, the behaviors are no longer differentially reinforced when they occur in a specific order. That is, reinforcement is no longer provided only in the presence of the tone. This modification should result in the elimination of R1, which is no longer necessary to receive reinforcement. R2 should continue to occur.

An extensive search of the literature revealed no studies that examined the unchaining procedure as it is described here. However, Nevin, et al. (1981) described a study which provides some information about the effects of providing an alternative way to access reinforcement in a chain schedule. In this study, two random interval chain schedules were in effect within each session (one on a right key and the other on a left key in a chamber). Training consisted of 36 sessions per day with 30 chains being

completed per session. Following training, response strength was assessed using signaled concurrent reinforcement. In this procedure, the center key was lit white when reinforcement was available for pecking on that key. The pigeons always switched to the center key immediately when lit and responding was less resistant to change in the initial links than in the terminal links. So, once the pigeons had completed the initial link schedule requirement, they were more likely to complete the terminal link requirement than to respond on the center key for alternative reinforcement. Although there are obvious differences between the procedures described in the Nevin et al. study and the unchaining procedures described above, similarities do exist. Both procedures involve establishing two responses in a chain or a chain schedule. Next, an alternative way to access reinforcement is made available (i.e., either a new response or the terminal response only) while reinforcement continues to be available for the already established chain of responses. If the results of Nevin et al. are generalizable to the unchaining procedure, the initial response in the chain should decrease when the terminal response produces reinforcement in the absence of the initial response.

Application

Few applied studies have directly examined the effects of procedures that may disrupt behaviors that occur within the context of response chains. It is important to study the ways in which behavior chains are influenced for several reasons. First, appropriate behavior within chains may be inadvertently extinguished or eliminated. For example, a chain could be established wherein an inappropriate behavior (e.g., banging on the kitchen pantry), results in a specific stimulus condition (e.g., the cabinet opening, displaying a cookie jar), and, in the presence of this stimulus, a second response (e.g., a

sign for “eat”) results in the delivery of food and termination of the stimulus condition (e.g., the cookie jar gets put back in the cabinet). In this situation, attempts to decrease the inappropriate behavior (e.g., by placing the banging on extinction) may lead to a decrease in the appropriate behavior (signing "eat").

Although this situation has not been directly examined, several studies on communication training and problem behavior have reported anecdotally that this type of behavior chain may have been inadvertently shaped during communication training. That is, the appropriate response appeared to become "chained" to the problem behavior (i.e., the individual engaged in problem behavior immediately followed by the communication response, which was reinforced, thereby strengthening the behavior chain.). For example, in one study, the components of a FCT treatment program for three individuals with problem behavior and mental retardation were evaluated (Wacker et al., 1990). The treatment included teaching the participants to communicate for the reinforcer identified to maintain problem behavior in the functional analysis. For two of the participants, either a time-out or a graduated guidance procedure was implemented contingent on problem behavior. Results indicated that both the FCT response and the time-out or graduated guidance procedure were necessary to reduce problem behavior. The authors noted that one of the participants bit the therapist and then emitted the communication response following therapist-delivered demands. They hypothesized that the chain, demand-bite-communicate, would have been inadvertently reinforced if the graduated guidance procedure had not been used.

In another study, functional communication training was evaluated alone and in combination with extinction and/or punishment for 4 individuals with severe mental

retardation and behavior problems (Fisher et al., 1993). The results indicated that FCT alone was not sufficient to reduce the participants' problem behavior and that the addition of punishment and/or extinction further reduced problem behavior. The authors hypothesized that the subjects' problem behavior had become chained to the communication response through FCT and that "behavior chains may develop because communication is being reinforced under stimulus conditions in which the probability of destructive behavior is high, thus increasing the probability of destructive behavior being followed by communication and reinforcement" (p. 33).

Not only do these results have implications for successful treatment with FCT, but, as noted above, the communication response may be inadvertently extinguished when attempts are made to decrease the problem behavior. For example, in one study three individuals were taught to emit a communication response to access the reinforcer found to maintain self-injurious behavior ([SIB] Shirley, Iwata, Kahng, Mazaleski, & Lerman, 1997). When SIB was exposed to extinction, both SIB and independent communication responses decreased simultaneously for one participant. The authors hypothesized that SIB and communication formed a response chain and that the FCT response was inadvertently extinguished when SIB underwent extinction.

In other cases, problem behavior may occur at the end of a chain of appropriate behaviors. Procedures designed to decrease the problem behavior may result in concomitant decreases in the appropriate behavior. For example, suppose that when a child says, "Help me," the child's mother goes and stands next to her. Once her mother is close to her, the child pinches her mom, and her mom gives her attention. If the caregiver used either noncontingent reinforcement (i.e., satiation) or extinction as treatment for

problem behavior (R2), “Help Me” (R1) may also decrease because the responses are closely linked in the chain. Alternatively, a series of appropriate behaviors might be inadvertently linked in a chain. If the contingencies for one response change (e.g., a new caregiver begins to reinforce the terminal response whether or not it follows earlier responses in the chain), the other appropriate responses may rarely occur.

It is also important to understand the circumstances under which chains are disrupted because undesirable behavior can occur in chains. For example, a behavior chain made up of two destructive behaviors, such as hitting (which receives parental attention) and banging on the pantry (which results in a cookie) could be established. Further understanding of the factors that affect responses that occur in chains could potentially aid in treatment selection and development. Finally, examining behaviors that occur in chains can provide more information about basic processes that have been widely discussed but rarely studied directly.

As noted above, few applied studies have examined the effects of procedures that may disrupt behavior chains. In a notable exception, Horner, Wuerch, and Boomer (1981) examined the effects of extinction on the performance of vocational response chains among three individuals with severe mental retardation. The individuals completed a nine-step chain that required the placement of electrical components in a circuit board blank (i.e., a circuit board without the electrical component). Prior to the evaluation, the behavior chain was taught using forward chaining. During baseline, the subjects received a preferred beverage for completing the chain. During extinction, the beverage was no longer provided when the chain was completed. Results indicated that all participants performed more slowly during extinction than during baseline (especially

during the first steps in the chain) and that the participants took longer to initiate the chain. However, responding did not completely extinguish for any of the subjects.

The interruption of behavior chains as a treatment for undesirable behaviors has been studied, although on a very limited basis. In one study, the severe vomiting of a twenty-one-year-old female with mental retardation was treated by delivering shock contingent on prevomiting behavior (Kohlenberg, 1970). The authors conceptualized vomiting as the end of a chain of behaviors beginning with stomach tension. The behavior selected for punishment was at the beginning of the chain because some basic findings have indicated that behaviors at the beginning of a chain tend to be weaker (Gollub, 1977). The behavior identified as occurring prior to vomiting was stomach tensions. Although a positive relationship between stomach tensions and vomiting was observed, there was not sufficient evidence to show that these behaviors occurred in a chain. Nevertheless, results indicated that the procedure was effective in reducing vomiting.

In another study, seizures were viewed as the terminal link in a chain of behaviors (Zlutnick, Mayville, & Moffat, 1975). The investigators wanted to decrease or eliminate the rate of seizures in children by identifying and modifying reliable pre-seizure behaviors. Preseizure behaviors varied and consisted of a fixed stare, a lowered activity level, subtle behavior change, arms raising above the head, and body tensing. The treatment procedure for four of the five participants consisted of shouting “no!” loudly and grasping the subjects by the shoulders and shaking them once. For the remaining participant, the preseizure behavior was raising her arms, and the treatment procedure consisted of placing her hands down to her sides for 5 seconds. The authors reported that

interrupting the pre-seizure behaviors reduced seizures in four of five subjects, whereas the frequency of pre-seizure behavior was reduced in only three subjects. Data were only shown for seizures (i.e., not pre-seizure behavior).

Finally, Fisher, Lindauer, Alterson, & Thompson (1998) hypothesized that the property destruction of two children was maintained by access to preferred materials for engaging in stereotypic behavior (i.e., property destruction and stereotypy formed a response chain that was maintained by the sensory consequences of stereotypy). First, the authors demonstrated that property destruction and stereotypic behavior persisted in the absence of social consequences. Next, they demonstrated that noncontingent delivery of previously broken items resulted in a decrease in property destruction, while stereotypy remained unaffected. The results supported the response chain hypothesis because the children continued to engage in the second response (stereotypy) when the first response (property destruction) was no longer necessary to receive the terminal reinforcer (the automatic reinforcer associated with stereotypy). However, the results did not demonstrate that property destruction and stereotypy were related or maintained by the sensory consequences of the latter response. To demonstrate that the two responses were part of a chain maintained by the hypothesized terminal reinforcer, data showing that both responses extinguished when stereotypy no longer produced the reinforcer (sensory consequence) would be needed.

Purpose

As noted above, it is important to study how behavior chains are influenced by such procedures as free access to reinforcement (i.e., satiation), extinction, and unchaining, as described by Michael (2000). Further evaluation of the manner in which

these factors affect response chains will be useful for (a) preventing the extinction or reduction of appropriate behaviors that occur within chains, (b) selecting and designing treatments for undesirable behaviors that occur in chains, and (c) providing more information about basic processes relevant to behavior chains that have been frequently discussed but seldom studied directly.

The purpose of this project was to study the effects of three procedures (i.e., extinction, satiation, unchaining) on behaviors that occur as part of a chain. For the series of experiments in this study, a two-response behavior chain was established in order to evaluate the procedures described by Michael. An applied analogue was used to better understand the basic relations between these processes and the responses in behavior chains. The behavior chain consisted of a response (R1) (e.g., signing “open”) that resulted in a small box opening and a food reinforcer being displayed. In the presence of the food reinforcer, another response (R2) (e.g., signing “eat”) resulted in delivery of reinforcement (a small piece of a preferred food item).

One procedure evaluated was satiation, which involved providing free access to food reinforcement for an established period of time prior to sessions. Periods of satiation might occur when caregivers inadvertently offer the same “treat” repeatedly for performing a behavior (e.g., potty training) or when the terminal reinforcer is freely available (e.g., provided as part of treatment with noncontingent reinforcement). It was expected that both R1 (i.e., “open”) and R2 (e.g., "eat") would decrease because the reinforcing efficacy of food had been reduced. Suppose a child engages in a chain of responses consisting of the verbal response, “help me,” (appropriate behavior) and aggression (inappropriate behavior) to receive attention. An intervention for the

aggression consisting of noncontingent attention could result in satiation of the terminal reinforcer in the chain (attention) and a decrease in the appropriate behavior “help me,” as well as a decrease in the problem behavior. It also was expected that R1 might initially show a more immediate decrease than R2, but that both responses would show similar reductions with continued exposure to the satiation procedure (e.g., Fischer and Fantino, 1968).

During the analysis of extinction effects, R1 continued to result in the box opening and the food appearing, but there were no differential consequences for R2 (e.g., “eat”). It was expected that the extinction of R2 would decrease the reinforcing effectiveness of the display of the food because it would no longer be paired with food delivery. Therefore, R1 (“open”) was expected to decrease because the presence of the food would lose its reinforcing effectiveness, and R2 (“eat”) was expected to decrease because it would no longer lead to food delivery (e.g., Mansfield & Rachlin, 1970). Extinction is often included as a component of interventions for problem behavior. When appropriate behaviors occur in a chain with problem behaviors, extinction of problem behavior may inadvertently result in extinction of appropriate behavior. However, because results of basic studies have been mixed, it was difficult to predict whether (a) both responses in the chain would decrease at the same rate (e.g., Mansfield & Rachlin, 1970), (b) greater decreases would be seen in R1 than in R2 (e.g., Catlin & Gleitman, 1973), or (c) R2 would decrease more rapidly than R1 (e.g., Fantino, 1965).

The unchaining procedure involved the reinforcer being equally available in the presence and the absence of the stimulus (Michael, 2000). The procedure consisted of reinforcing R2 (i.e., “eat”) any time it occurred, independent of R1 (e.g., “open”) being

emitted. R1 was still followed by the food being displayed. However, the food being displayed would no longer function as an S^D for R2 or a conditioned reinforcer for R1 because reinforcement was equally available in the presence and absence of the food being displayed. This could happen in applied settings if, for example, caregivers inadvertently shaped a chain of appropriate responses (e.g., "open" followed by "eat") and then began to reinforce the terminal response ("eat") whether or not it followed earlier responses in the chain. It was expected that R1 would decrease and that R2 would remain at baseline levels or increase (e.g., Nevin et al., 1981). In the example given above, if a new caregiver began to reinforce only later responses in the chain, earlier appropriate responses may be eliminated. For children with few appropriate responses, this could have significant implications.

GENERAL METHOD

General Information

Participants and Setting

Five children participated in the study. Teachers or caregivers referred the children after receiving information about the study. Bonnie was a 4-year-old girl diagnosed with autism. She communicated by shaking her head, pointing at objects, and pulling people, and she exhibited one vocal response ("no"). She received speech services at school twice weekly with a speech therapist who reported that sign training had been unsuccessful prior to her participation in this study. Bonnie participated in all three studies. Leroy was a 4-year-old boy diagnosed with developmental delays. He communicated by pointing at objects and pulling people. Leroy had no prior exposure to sign training. He participated in the satiation study. He did not participate in the other two studies because his family was no longer able to provide transportation to the early intervention program. Timmy was a 3-year-old boy diagnosed with Down syndrome who attended an early intervention preschool for children with developmental disabilities. At school, he communicated by shaking his head "yes" and "no," pointing at objects, and pulling people. His speech therapist and his special education preschool teacher reported that they had unsuccessfully attempted sign training with Timmy and that he did not engage in any signing at school. His mother reported that he communicated at home using several signs, but that the signs used in this study were not in his signing repertoire. He participated in the extinction and unchaining studies. He did not participate in the satiation study because the school session was ending, and he was then unavailable for sessions. Don was an 11-year-old boy diagnosed with autism, obsessive-compulsive

disorder, disruptive behavior disorder, seizure disorder, and mental retardation (level unspecified). He was an inpatient on a unit for children with severe behavior problems for the assessment and treatment of self-injurious behavior. He communicated by pointing at objects and pulling people. He used a “flip-n-talk” book during speech therapy and at his school. Don received speech therapy during his admission and began using a few signs on the living unit over the course of this study (i.e., “no”, “finished,” and “more”). He participated in all three studies. Sammy was a 10-year-old boy diagnosed with autism, mood disorder – not otherwise specified (NOS), disruptive behavior disorder – NOS, moderate mental retardation, and attention deficit hyperactivity disorder. He was an inpatient on the same unit as Don where he was receiving treatment for severe self-injury, aggression, and disruptive behavior. He had no reliable method of communication prior to this study. He participated in the satiation and extinction studies. He did not participate in the unchaining study because he was discharged from the inpatient unit.

Bonnie’s sessions were conducted in the school library, cafeteria, and a small room in a building that housed a university-based summer program. The library contained one large table, a small table, several chairs, bookcases, and books. The cafeteria contained approximately 15 long tables with child-sized chairs, a water fountain, and an opening in the wall for food service. The small room in the campus building contained a small table and several chairs. Timmy’s sessions were also conducted in the cafeteria at his school (see cafeteria description for Bonnie). Leroy’s sessions were conducted in an empty classroom at his early intervention program. The classroom contained a small table with chairs, a teacher’s desk, a changing table,

bookcases with toys and books on them, and two toy boxes. Don's sessions were conducted in a bedroom on the inpatient unit. The bedroom contained two hospital beds, a small table, two dressers, and several chairs. Sammy's sessions were conducted in a multipurpose room on the inpatient unit. The multipurpose room contained several tables and chairs, cabinets, plastic bins with toys, and a sink.

Response Measurement and Reliability

One to two observers collected data using paper data sheets during training and laptop computers during all subsequent sessions. Data were collected on child and experimenter behavior. Child communication responses were defined on an individual basis after consulting with parents, speech therapists, and educators and consisted of manual signs for "open" and either "eat" or a specific food name (e.g., "popcorn"). Bonnie, Leroy, Don, and Sammy's sign for "eat" consisted of a motion similar to the American Sign Language (ASL) sign "eat". For Bonnie and Don, this consisted of placing the pointer finger, middle finger, and thumb together and touching them to the lips, which is identical to the sign for "eat" specified in the ASL dictionary. During training, Leroy and Sammy had difficulty acquiring the ASL sign for "eat;" therefore, a less complex sign was taught. This sign consisted of the child pointing to the mouth with the pointer finger. Timmy's sign for popcorn was the ASL sign for "popcorn," which consisted of Timmy raising the pointer finger on one hand in the air followed by raising the pointer finger on the other hand and repeating the motion once or twice. If he stopped and restarted the motion, data collectors recorded it as a new occurrence of the response. The specific food name was chosen for Timmy because he had previously learned several signs but had not been taught the sign for popcorn. Leroy, Sammy, Don and Bonnie had

never successfully learned any manual signs prior to this study. Therefore, a more general sign (i.e., “eat”) was chosen rather than a specific food name so that these participants would be able to request multiple food items after the conclusion of the study.

For Bonnie, Timmy, and Don, the sign for “open” was similar to the ASL sign for “open”. This sign consisted of the children placing their hands together (palm side) and then moving them apart like they were opening a book. Initially, the ASL sign for open was chosen for all children. However, Leroy and Sammy were taught a less complex sign consisting of tapping the box with one finger after they had difficulty learning the “open” sign described above.

Experimenter behaviors consisted of programmed responses to child behavior. Specifically, if a child signed “open,” the experimenter opened a box and displayed the food item. Next, if the child signed “eat,” the experimenter delivered a small piece of the food item. Therefore, experimenter behavior consisted of displaying the reinforcer (opening the box) and delivering the reinforcer (delivering the food item) within 5 s of the child's behavior.

During initial communication training, communication responses were scored as independent or prompted. Independent responses were defined as communication responses that occurred prior to a therapist prompt. Prompted communication responses were defined as responses that followed a therapist prompt within 10 s. Following training, independent communication responses were scored as appropriate or inappropriate. Appropriate communication was defined as a response that occurred when the relevant S^D was present (i.e., signing “open” when the box was closed; signing “eat” when the box was open). Inappropriate communication was defined as a response that

occurred in the absence of the relevant S^D (e.g., signing “open” when the box was already open; signing “eat” when the box was closed).

Data on communication responses and reinforcer delivery (food delivery) were collected using frequency recording. Data on reinforcer display (box open) were collected using duration recording. The rate of independent “open” and “eat” responses was calculated by dividing the total number of responses by total session time (10 min). In addition, responses per minute of independent inappropriate “eat” and “open” responses were calculated based on the amount of time that the response could have occurred. Inappropriate “eat” responses per minute were calculated by dividing the number of responses by the amount of time the box was closed. Inappropriate “open” responses per minute were calculated by dividing the number of responses by the amount of time the box was open (food was displayed). Finally, the percentages of inappropriate “eat” and inappropriate “open” responses in each session were calculated by dividing the number of inappropriate responses by the total number of responses and multiplying by 100. These data were used to evaluate the degree to which each response functioned as a member of the behavior chain (i.e., indicated acquisition and maintenance of the two-response behavior chain).

A second observer recorded responding during 95.2%, 41.4% and 33.3% of satiation, extinction, and unchaining sessions for Bonnie, respectively. A second observer recorded responding during 35.1% and 45.7% of extinction and unchaining sessions for Timmy, respectively. A second observer recorded responding during 55.6% of satiation sessions for Leroy. A second observer recorded responding during 34.4% and 49.1 % of sessions for Sammy during satiation and extinction, respectively. For Don, a

second observer recorded responding during 47.5%, 35.1%, and 38.5 % of satiation, extinction, and unchaining sessions, respectively.

Mean percentage of interobserver agreement was calculated using the exact agreement method. Sessions were divided into 10-s intervals. Agreement was defined as both observers agreeing on the number of times the behavior occurred in any given interval. Disagreement was defined as a discrepancy between the observers in any given interval. The number of agreements was divided by the number of agreements plus disagreements, and the resulting value was multiplied by 100%. Mean percentage of agreement for the satiation, extinction, and unchaining evaluations for Bonnie was 97.5%, 92.1%, and 96.3%, respectively. Mean percentage of agreement for the satiation evaluation for Leroy was 97.5%. For Timmy, the mean percentage of agreement for the extinction and unchaining evaluations was 94.6% and 92.9%, respectively. Mean percentage of agreement for the satiation and extinction evaluations for Sammy was 97.1% and 97.8%, respectively. For Don, the mean percentage of agreement for the satiation, extinction and unchaining evaluations was 96.8%, 97.1%, and 95.9%, respectively.

Preference Assessment

A paired choice preference assessment was conducted with each participant to identify preferred foods (e.g., Fisher, Piazza, Bowman, Hagopian, Owens, & Slevin, 1992). Foods that were identified as preferred by parents or teachers were presented in pairs until all possible pairs were presented. If the child chose one of the items presented, the item was given to the child. If no choice was made, the pair was re-presented. A hierarchy of preference was then calculated by dividing the number of times an item was

chosen by the total number of times it was presented and multiplying by 100%. Items identified as highly preferred from the preference assessment were used in the subsequent studies as the primary reinforcer. The item chosen to be the primary reinforcer for Bonnie and Timmy was popcorn. The items chosen for Leroy, Sammy, and Don were Nerds® candy, peanut butter and cheese crackers, and oatmeal pies, respectively. However, prior to the experimental manipulations described below, two children took many sessions to acquire the responses from the onset of the initial training sessions, and they began to consume the reinforcers slowly or not at all. For each child, direct care staff suggested alternative items that were substituted for the original items. Sammy began receiving Cheetos®, and Don began receiving grapes. Responding for both children increased when the change was made, and training continued with the new item.

Communication Assessment

A communication assessment was conducted with each child to obtain a baseline level of the targeted behaviors prior to training and to identify communication responses that were and were not in the child's repertoire. The child was seated in a chair next to a table or desk. A small box containing the child's preferred food was placed on the table or the desk. The therapist showed the child that the food item was in the box and then closed the lid. If the child communicated appropriately (e.g., signed "open", said "please"), the therapist would have opened the box. Appropriate communication was defined as any attempt to communicate to open the box using speech, sign language, or recognizable gestures. The box would have remained open for 1 min or until the child communicated for the food. The food would have been given to the child if the child communicated appropriately (e.g., said "eat," signed "eat" or the name of the food).

Appropriate communication was defined as any attempt to communicate to eat using speech, sign language, or recognizable gestures. No child exhibited appropriate communication during the communication assessment. However, several children attempted to open the box themselves. Attempts to open the box were blocked. Neither Sammy nor Leroy, who were subsequently taught to point to the box during training, exhibited this response during the communication assessment, although both children touched the box.

Initial Chain Training

Two communication responses were taught using a backward chaining procedure during 10-min sessions. All appropriate responses were ignored with the exception of those responses identified as R1 (“open”) and R2 (“eat” or “popcorn”). All inappropriate behavior was ignored. Response two (R2) was taught first. The reinforcer (food) was visually present to establish the presence of the reinforcer as an S^D for communication. The correct response (R2) was prompted every 5 s (timing began following presentation of the reinforcer). The prompt delay increased by 5 s every 10 trials. A three-step prompting procedure consisting of a verbal prompt, a verbal prompt with a model, and a physical prompt was used. The verbal prompt consisted of a verbal statement (e.g., “sign open”). The verbal prompt with a model consisted of a verbal statement and a demonstration of the response (e.g., “sign open like this” while modeling the response). The physical prompt consisted of physical guidance to complete the correct response. The prompts were gradually faded by first eliminating the physical prompt, then the model prompt, and eventually the verbal prompt. The physical prompts were discontinued when the verbal prompt delay reached 60 s, the model prompt was

discontinued when the verbal prompt delay reached 120 s, and all prompts were discontinued when the delay reached 180 s or when the child communicated independently 5 consecutive times for 2 consecutive sessions. This procedure was used to fade prompts for all children except Sammy, who failed to acquire independent communication responses as the prompts were faded. Therefore, prompts were faded more slowly. The most intrusive level of prompting was eliminated following two consecutive sessions during which that level of prompting was not needed (e.g., the physical prompt was eliminated following two consecutive sessions during which physical prompts were not delivered because the child displayed the response following less intrusive prompts) until Sammy independently displayed the sign. The reinforcer (a small piece of food) was delivered contingent on the correct response (independent or prompted). Phase one was complete when the child independently displayed R2 five consecutive times for two consecutive sessions.

Next, response one (R1) was taught within the context of a chain. During training, the food was in a small box. The experimenter showed the participant that the food was in the box prior to the start of a session and then closed the box. Communication to open the box (R1) was prompted every 5 s. Timing began after the reinforcer was placed in the box, and the box was closed. The experimenter used the prompts and prompting fading procedure described above. Contingent on R1, the box was opened, and the reinforcer (food) was displayed. The experimenter then waited for R2. Contingent on R2, a small piece of food was delivered, and the remaining food was returned to the box. A trial ended (i.e., the food was be returned to the box) when R2 occurred or if R2 did not occur within 1 min of R1. All inappropriate communication

responses (i.e., responding for the reinforcer before the box was opened and the reinforcer was displayed; responding to open the box when it was already open) and all other responses were ignored. Training was terminated when the participant independently displayed R1 10 consecutive times for 2 consecutive sessions.

Experimental Design

The effects of satiation, extinction, and unchaining on the response chain were evaluated in a reversal design with the exception of Bonnie's satiation evaluation, which was conducted in an AB design.

General Procedures

The procedures and results for each study are described separately below. Bonnie first participated in the unchaining study, followed by the extinction and satiation studies. Leroy participated in the satiation study only. Timmy participated in the unchaining study first and then the extinction study. Sammy participated in the satiation study and then the extinction study. Don participated in the extinction study, followed by unchaining and then satiation. All sessions were 10 min. All appropriate responses were ignored with the exception of those responses identified as R1 and R2. All inappropriate behavior was ignored. Prior to each session (i.e., before the data collection began), the children were prompted to perform the chain in order to expose them to the contingencies in effect for the session.

Experiment 1: Effects of Satiation on the Chain

Procedures

Bonnie, Leroy, Sammy and Don participated in the evaluation of satiation on the chain.

Baseline. Procedures were identical to those implemented in R1 training sessions but no prompts were delivered. That is, the food was placed in a small box on a table or chair next to the child. Prior to the start of the session, the experimenter showed the child that the food was in the box. Contingent on R1 ("open"), the experimenter opened the box, and the food was displayed. Contingent on R2 ("eat"), the experimenter delivered a small piece of food to the child, placed the remaining food back in the box, and closed the box. If R2 did not occur within 1 min of R1, the box was closed. The child was then required to display R1 again before R2 to receive food. All inappropriate communication responses (i.e., communicating for the food before the box was opened and responding to open the box when it was already open) were ignored. This phase continued until less than 1 inappropriate R2 response occurred per minute, and responding was stable for 3 consecutive sessions.

Satiation. Prior to this phase, a satiation assessment was conducted in which the participant had continuous, noncontingent access to the food reinforcer. The amount of time that passed until the participant stopped consuming the food item for 5 min was determined, and all pre-session satiation periods were set at this duration for this phase of the study. However, Bonnie and Don did not stop consuming the reinforcer after 30-min access to the food during the satiation assessment. Due to concerns about excessive food consumption, 30 min was used as their satiation period. The pre-session satiation period for Bonnie, Leroy, Sammy and Don was 30, 25, 26, and 30 minutes, respectively. Prior to each session, the child was given free access to the reinforcer for the duration of these satiation periods. No more than two sessions were conducted following one pre-session satiation period in order to control for the amount of time that passed between the

satiation period and sessions. With the exception of the pre-session access to the food reinforcer, sessions were identical to baseline sessions. The purpose of this condition was to evaluate the effects of satiation on R1 (i.e., communicating to open the box) and R2 (i.e., communicating for food).

Results and Discussion

Independent “eat” and “open” responses during the satiation evaluation are depicted in the top, middle and bottom panels of Figure 1 for Bonnie, Leroy, and Sammy, respectively, and in Figure 2 for Don. The average percentage of inappropriate “open” and “eat” responses during the last three sessions of each condition are depicted in Table 1 for all participants.

Both “open” and “eat” responses were high and relatively stable for Bonnie in baseline, and no reductions in these responses were observed during the satiation phase. That is, 30 min of free access to and consumption of the reinforcer prior to the sessions did not result in any noticeable decrease in responding, so the analysis was terminated after 6 sessions. Inappropriate “open” responses averaged just 16.9% of the total “open” responses and inappropriate “eat” responses averaged just 0.4% of the total “eat” responses during the last three sessions of the baseline phase (see Table 1). Bonnie continued to engage in low percentages of inappropriate “open” and “eat” responses during the satiation condition. Thus, the two responses continued to function as members of a behavior chain throughout the assessment. To summarize, results for Bonnie indicated that 30 min of free access to the terminal reinforcer did not result in decreases in either the “eat” or “open” response.

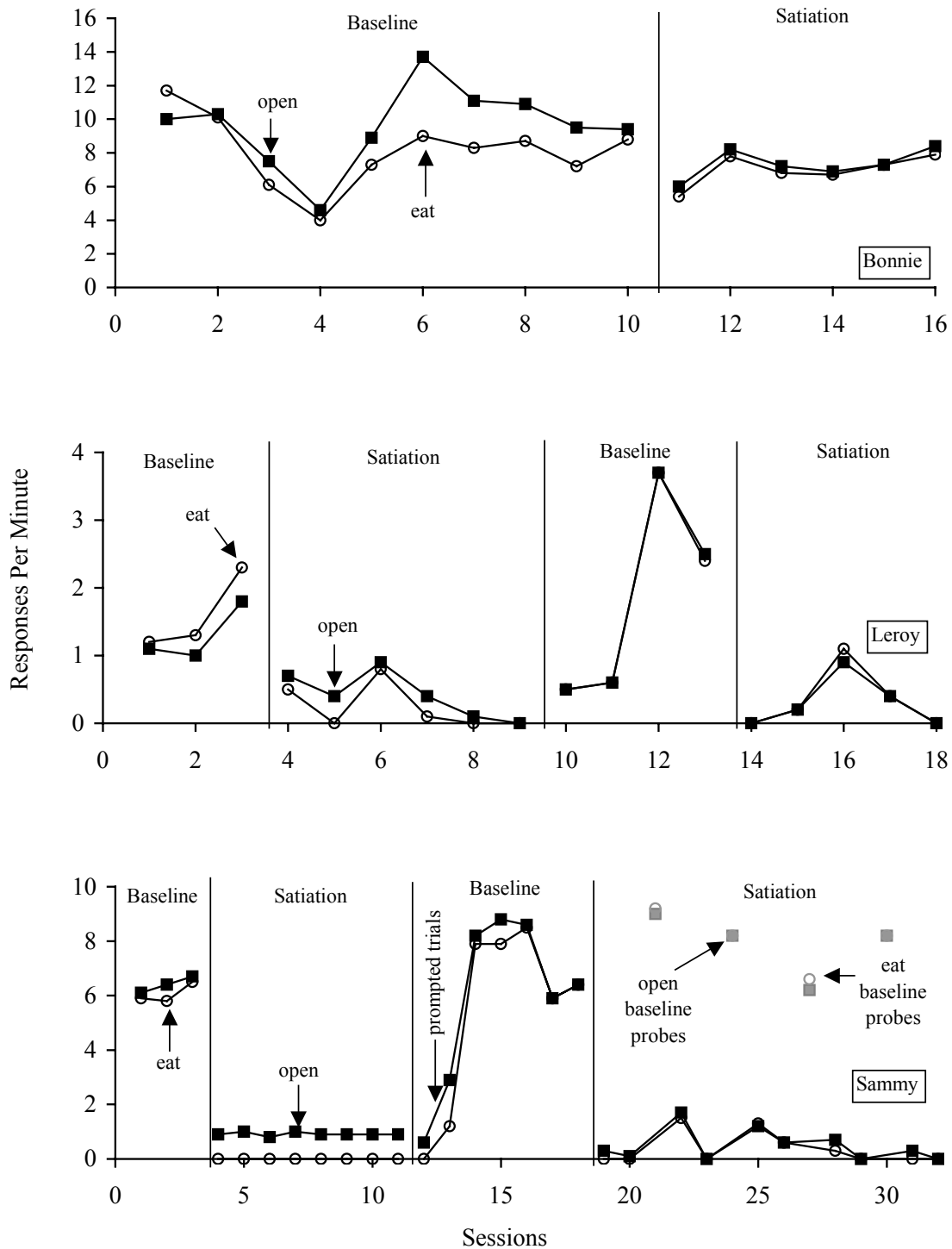


Figure 1. Responses per minute of “open” and “eat” responses during the satiation evaluation for Bonnie (top panel), Leroy (middle panel), and Sammy (bottom panel). “Open” responses are depicted by the filled squares and “eat” responses are depicted by the open circles.

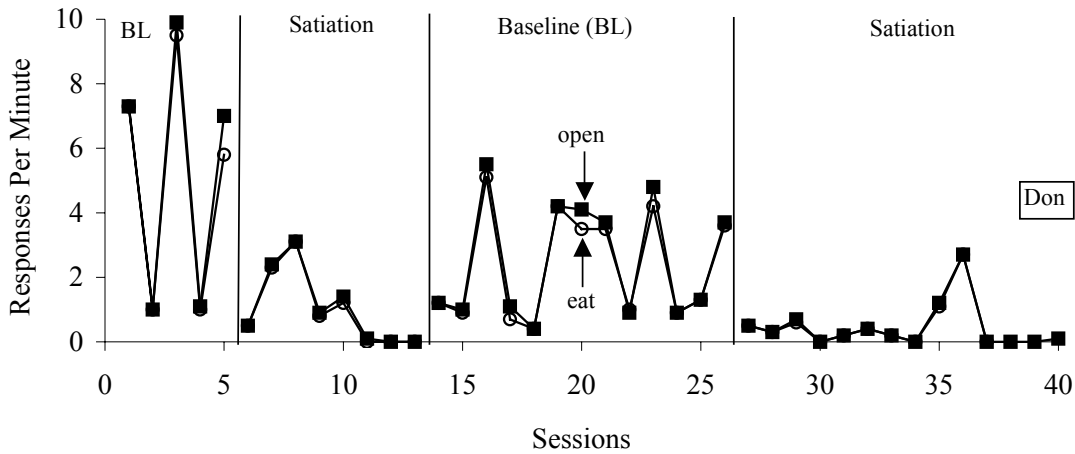


Figure 2. Responses per minute of “open” and “eat” responses during the satiation evaluation for Don. “Open” responses are depicted by the filled squares and “eat” responses are depicted by the open circles.

Table 1

Average percentage of inappropriate “open” and “eat” (or “popcorn” for Timmy) responses for the last three sessions of each phase

	<u>Satiation</u>				<u>Extinction</u>				<u>Unchaining</u>			
	<u>Baseline</u>		<u>Satiation</u>		<u>Baseline</u>		<u>Extinction</u>		<u>Baseline</u>		<u>Unchaining</u>	
	<u>open</u>	<u>eat</u>	<u>open</u>	<u>eat</u>	<u>open</u>	<u>eat*</u>	<u>open</u>	<u>eat*</u>	<u>open</u>	<u>eat*</u>	<u>open</u>	<u>eat*</u>
Bonnie	16.9	.4	4.2	1.8	5.3	1.7	0	0	0	1.4	4.1	91
Timmy	-	-	-	-	5.2	9.9	0	0	0	27.2	0	100
Leroy	1.5	9.1	0	12.9	-	-	-	-	-	-	-	-
Sammy	1.3	.3	0	0	0	.7	0	31.0	-	-	-	-
Don	9.4	2.1	0	0	4.1	0	0	0	7.1	0	0	96.6

* "popcorn" for Timmy

For Leroy, moderate levels of “open” and “eat” occurred during baseline, and low percentages of the total responses were inappropriate ($M = 3.0\%$ for "open" and $M = 16.4\%$ for "eat"). The responses decreased simultaneously and fairly quickly during the satiation condition. Slightly greater decreases were observed for “eat” responses relative to “open” responses, but the same overall pattern of reduction was observed with both responses. “Eat” responses were eliminated completely in the fifth satiation session and “open” responses were eliminated in the sixth satiation session. During a return to baseline, levels of both “open” and “eat” increased above those observed in the satiation condition by the third session. No inappropriate “open” responses were observed during this phase and only 1.8% of total “eat” responses were inappropriate during the last three sessions of the second baseline phase. With a return to satiation, “open” and “eat” responses decreased simultaneously and immediately, followed by a brief increase and then a reduction to 0 by the fifth session. Across both satiation phases, Leroy engaged in low levels of inappropriate "open" and "eat" responses, suggesting that the two responses continued to function as members of a behavior chain. To summarize, pre-session access to the food reinforcer resulted in substantial decreases in “open” (R1) and “eat” (R2). In addition, during the first satiation phase, “eat” decreased slightly faster than “open”. However, this effect was not replicated in the second satiation phase.

Responses per minute of “open” (R1) and “eat” (R2) were high and stable during the initial baseline for Sammy. The average percentage of inappropriate responses was low during the last 3 sessions ($M = 0.6\%$ for "open" and $M = 2.6\%$ for "eat"), indicating that the responses functioned as members of a behavior chain prior to introducing the satiation manipulation. With the introduction of satiation, “eat” responses decreased to

zero immediately. “Open” responses decreased relative to baseline but maintained at approximately 1 response per minute across 8 sessions. Upon returning to baseline, “eat” responses did not increase during the first session. Therefore, 30 prompted trials were conducted to determine if the food still functioned as a reinforcer. For these trials, the therapist used a three-step prompting procedure to prompt Sammy to engage in the chain “open-eat.” Across the prompted trials, Sammy began to engage in the chain with less assistance and was independently exhibiting the chain by the end of the 30 trials. (Data collected during these trials are not displayed in the figure.) Following these prompted trials, baseline sessions resumed, and both responses increased immediately. Across the last three sessions of the second baseline phase, low percentages of inappropriate responses were observed ($M = 0\%$ for “open” and $M = 5.9\%$ for “eat”). Because prompted trials were conducted at the beginning of the second baseline phase, baseline probe sessions were alternated with satiation sessions during the second satiation phase. These sessions were 5 min and were identical to the baseline sessions described above. One baseline probe session was conducted per day prior to the pre-session satiation period. During the return to satiation, “open” and “eat” responses decreased immediately and simultaneously although they continued to occur at low rates for several sessions. Response rates during the baseline probes were high and consistent with those from the previous phases, indicating that pre-session access to the reinforcer decreased the effectiveness of food and the sight of the food/open box as reinforcers. During the last three sessions of the satiation phases, inappropriate responses accounted for only 0% and 12.9% of the total “open” and “eat” responses, respectively. Overall, results of Sammy’s satiation evaluation indicated that pre-session access to the food reinforcer resulted in

immediate decreases in R1 and R2. Differences were observed in the reduction of R1 when compared to R2 (i.e., “open” responses were never eliminated) during the first satiation phase. This difference was not replicated in the second satiation phase when similar reductions in both responses occurred.

“Open” and “eat” responses were high and variable for Don during the first baseline phase, and the percentage of inappropriate responses was low ($M = 10.4\%$ for open and $M = 0.4\%$ for eat during the last 3 sessions). With the introduction of satiation, both responses decreased. However, responding continued across the first five satiation sessions. After three initial satiation sessions, both “open” and “eat” responses decreased simultaneously across the next three sessions and did not occur during the final two sessions. “Open” and “eat” responses were moderate and variable during the second baseline phase. Overall responding during the second baseline phase was lower than observed during the first baseline phase. During the last three sessions of the baseline phase, inappropriate “open” responses averaged 8.3% of the total open responses and inappropriate “eat” responses averaged just 3.7% of the total “eat” responses. During the second satiation phase, “eat” and “open” responses decreased immediately. Both responses continued to occur at low levels for the first 8 satiation sessions (with the exception of 2 points at 0 for both responses), followed by an increase in both responses for 2 sessions, and a decrease back to 0 for 3 sessions. One “eat” and one “open” response were observed during the last session. No inappropriate “eat” or “open” responses were observed during the last three sessions of the satiation phases. To summarize, results for Don indicated that pre-session access to the terminal reinforcer resulted in a simultaneous decrease in and near elimination of R1 and R2.

To briefly summarize the results of Study 1, pre-session access to the terminal food reinforcer suppressed the response chain for three of the four participants. For Leroy, Sammy and Don, substantial reductions in “open” and “eat” responses were observed within the first few satiation sessions and in general, a decreasing trend in these responses was observed across the satiation phases. For two of the children (Leroy and Sammy), “eat” (R2) decreased more quickly than “open” (R1) in the initial satiation phase, and both responses decreased simultaneously during the second satiation phase. For one child (Don), R1 and R2 decreased simultaneously during both satiation phases, and for the other child (Bonnie), no decreases in either response were observed during satiation.

As discussed in more detail below (see “General Discussion”), several clinical implications can be drawn from these findings. First, results have implications for the use of NCR as a treatment for problem behavior that may occur as part of a chain. NCR involves delivering reinforcement on a response-independent basis. Typically, the individual receives free access to the same reinforcer that was found to maintain the problem behavior. Reductions in problem behavior via NCR have been attributed to satiation effects. Thus, results of the current study indicate that other behaviors (either appropriate or inappropriate) may also decrease under NCR if these behaviors are linked in a chain with the target behavior. Results of the satiation evaluation also have implications for inadvertently reducing multiple behaviors when environmental changes result in a satiation effect. For example, if a caregiver begins to give a child a lot of cookies, the child will stop asking for cookies as well as any responses that may be chained to that response.

Nevertheless, these results are somewhat inconsistent with the majority of basic findings on satiation effects and response chains (Fischer & Fantino, 1968; Malott, 1966; Mandell, 1980). That is, the terminal response was disrupted more readily than the initial link rather than vice versa although this pattern was replicated across but not within subjects. One basic study (Fischer & Fantino, 1968) found an interaction between the effects of satiation on response chains and the length of exposure to the satiation manipulation. That is, responding decreased simultaneously in both links after four sessions even though responding in the initial link but not the terminal link decreased when pre-session access to food was first introduced. Furthermore, Morgan, Einon, and Morris (1977) reported that rats who were pre-fed prior to entering a maze continued to complete the initial responses in the chain at a similar rate to baseline, whereas the terminal responses decreased. These results are more consistent with the current findings and will be discussed in greater detail below (see “General Discussion”).

Experiment 2: Effects of Extinction on the Chain

Procedures

Bonnie, Timmy, Don and Sammy participated in the evaluation of extinction on the chain.

Baseline

Procedures were identical to those conducted in the baseline sessions of Study 1.

Extinction

Procedures were identical to those implemented in the baseline sessions with one exception. R1 ("open") resulted in the box opening, but the box closed and no food was delivered contingent on R2 ("eat" or "popcorn"). The purpose of this condition was to

examine the effects of extinction of R2 (i.e., communicating for food) on both R1 (i.e., communicating to open the box) and R2.

Results and Discussion

Independent “open” and “eat” (or “popcorn” for Timmy) responses during the extinction evaluation are depicted in the top, middle, and bottom panels of Figure 3 for Bonnie, Timmy, and Don, respectively, and in Figure 4 for Sammy. The average percentage of inappropriate “open” and “eat”/“popcorn” responses for the last three sessions of each condition in the extinction evaluation are depicted in Table 1 for all participants. All of the children who participated in the extinction evaluation engaged in low levels of inappropriate communication responses during the last three sessions of each phase, with the exception of Sammy whose inappropriate “eat” responses accounted for 31% of total eat responses during extinction (see further discussion below). Thus, the responses continued to function as members of a behavior chain throughout the evaluation.

Bonnie's responses during the baseline phases of the extinction evaluation were high and variable. When extinction was introduced, an immediate decrease was observed for both responses. “Eat” decreased more rapidly than “open,” but both responses were eliminated by the fourth extinction session. When extinction was reintroduced after a return to baseline, rates of “open” and “eat” again decreased immediately. However, Bonnie continued to engage in low rates of “open” throughout this phase. Only one “eat” response was observed, and it occurred during the first extinction session. Thus, overall

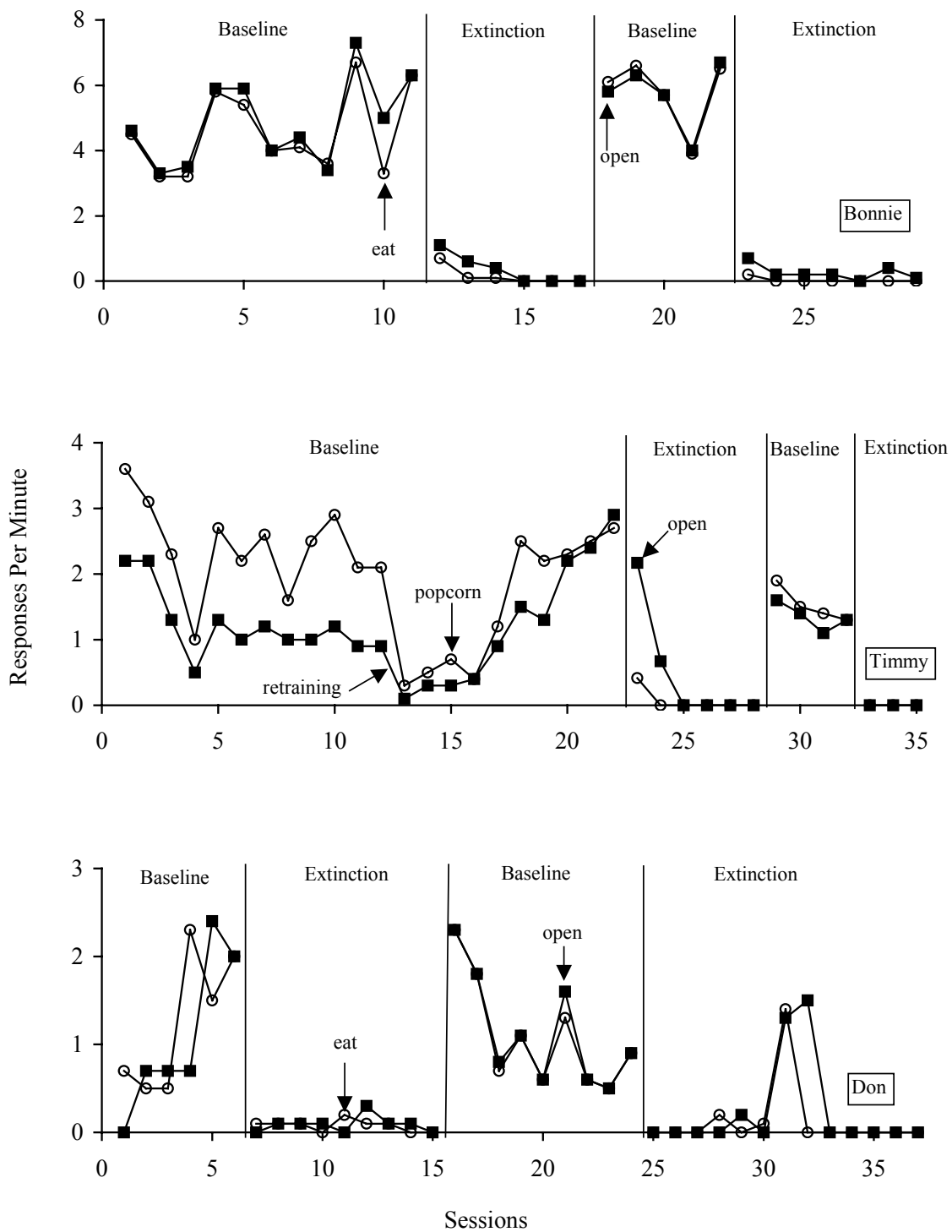


Figure 3. Responses per minute of “open” and “eat” or “popcorn” responses during the extinction evaluation for Bonnie (top panel), Timmy (middle panel), and Don (bottom panel). “Open” responses are depicted by the filled squares and “eat” or “popcorn” responses are depicted by the open circles.

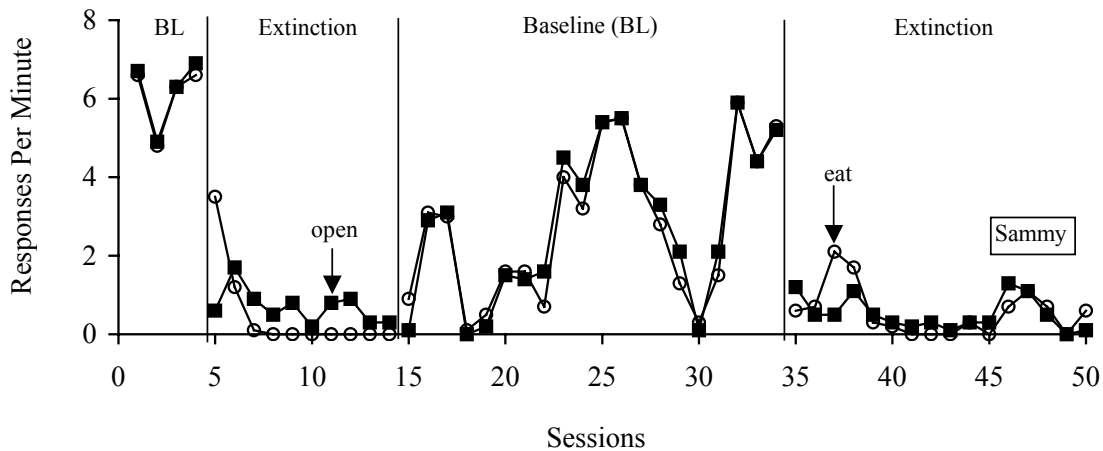


Figure 4. Responses per minute of “open” and “eat” responses during the extinction evaluation for Sammy. “Open” responses are depicted by the filled squares and “eat” responses are depicted by the open circles.

results for Bonnie indicated that extinction (withholding the terminal reinforcer) produced a rapid decrease in both responses in the chain and that R2 decreased more rapidly than R1.

During Timmy’s initial baseline phase, a three-response chain – “popcorn-open-popcorn” – appeared to become established inadvertently. This accounts for the higher level of “popcorn” responses relative to “open” responses during the first half of the baseline. In fact, the overall percentage of inappropriate “popcorn” responses observed during the first baseline phase was 42.3%. Thus, baseline sessions were temporarily discontinued after session 12, and 15 retraining sessions were conducted. During retraining, inappropriate “popcorn” responses (i.e., those that occurred prior to “open”) were blocked, and only the chain “open-popcorn” was reinforced. Retraining sessions are not depicted on the figure. These sessions continued until Timmy engaged in the correct chain of responses (i.e., “open-popcorn”) five consecutive times for two sessions. Following retraining (beginning with session 13), both “open” and “popcorn” responses

decreased initially and then increased. Inappropriate “eat” responses decreased and averaged 8.2 % of the total “popcorn” responses during the last three baseline sessions, indicating that the response functioned as a member of the behavior chain prior to extinction. Inappropriate “open” responses accounted for 8% of total responses during the last three sessions of the first baseline phase. With the introduction of extinction, “popcorn” responses decreased immediately and were eliminated after one session. “Open” responses did not decrease during the first extinction session but did decrease during the second session and were eliminated completely by the third extinction session. Inappropriate “open” and “popcorn” responses were not observed during the last three extinction sessions. During a return to baseline, moderate and stable responding was observed for “open” and “popcorn” responses. Mean percentage of inappropriate “popcorn” and “open” responses during the last three sessions of the second baseline were just 11.6 % and 2.4%, respectively. With the reintroduction of extinction, “open” and “popcorn” responses never occurred. The participants were exposed to the contingencies prior to each session, which could explain the absence of responding in the first extinction session. Overall, extinction (i.e., withholding the terminal food reinforcer) resulted in a decrease in both members of the behavior chain for Timmy. R2 (“popcorn”) decreased more rapidly than R1 (“open”) during the initial exposure to extinction.

For Don, levels of responding increased across the initial baseline condition. With the introduction of extinction, responding decreased immediately, although “open” and “eat” continued to occur about one time per session for several sessions. Responding was initially high during the return to baseline; both responses then decreased and

became relatively stable. When extinction was reintroduced, “open” and “eat” decreased to zero immediately. Both responses recovered briefly during session 31. “Eat” returned to zero during session 32 and “open” returned to zero during session 33. Overall, results for Don indicated that extinction had a rapid effect on the response chain and that both responses were similarly influenced by extinction.

Sammy engaged in high rates of independent “open” and “eat” responses during the initial baseline phase of the extinction evaluation. When extinction was introduced, both responses decreased immediately although “open” never completely extinguished during this phase. “Eat” responses were higher than “open” responses during the first extinction session, but “eat” decreased to zero within three sessions and never occurred for the remainder of the phase. During a return to baseline, rates of “open” and “eat” were highly variable. With the reintroduction of extinction, both responses slowly decreased to zero across nine sessions. “Eat” responses were somewhat higher than “open” responses during the early part of extinction (the 3rd and 4th sessions). However, “eat” decreased to zero levels by the 7th session while at least one “open” response occurred during all extinction sessions with the exception of the next to last session. This pattern is similar to that observed during the first extinction phase. During sessions 46-48, both responses increased briefly and then decreased again. The rate of eat responses averaged .43 over the last three sessions of extinction, although only one of these responses was an appropriate “eat” response. Inappropriate “eat” responses occurred during 8 of the 16 sessions ($M = 37.2\%$). It should be noted that Sammy began to engage in stereotypic behavior on the living unit and in session that consisted of vocalizing, placing one hand on an ear, and placing the pointer finger of the other hand on the mouth.

This last response could not be distinguished from Sammy's "eat" response and was scored as such, thus accounting for the higher level of inappropriate "eat" responses during this phase. Regardless, responding was not completely extinguished in the phase and further sessions could not be conducted because Sammy was discharged from the inpatient unit. Overall, withholding the terminal food reinforcer resulted in an immediate decrease in "open" and "eat" responses for Sammy. Although response reduction was initially more rapid for R1 than R2, R2 ("eat") decreased to a lower level than R1 ("open") across extinction sessions.

Overall, extinction resulted in immediate decreases in both members of the response chain for the four individuals who participated in this study. In addition, R2 ("eat" or "popcorn" for Timmy) decreased to zero levels more quickly than R1 ("open") for three of the participants (Bonnie, Timmy, and Sammy). In fact, for Sammy, "open" never completely extinguished during the first extinction phase. This pattern of responding was replicated in the second extinction phase for Bonnie, as well as for Sammy to some degree. Overall, results indicated that extinction had a more rapid effect on the second response in the chain, "eat" ("popcorn" for Timmy), than the first response, "open".

A behavior chain may be exposed to extinction (i.e. the terminal reinforcer may be withheld) when the terminal response cannot be reinforced (e.g., the reinforcer is unavailable or inconvenient to deliver in some situations) or if caregivers decide to deliberately withhold the reinforcer for the terminal response (e.g., the response is inappropriate or occurs too frequently). Thus, results of the current study have important clinical implications. For example, when extinction is used as part of treatment for

problem behavior that occurs as part of a chain, any appropriate behavior that is an earlier member of the response chain may also extinguish. Additional clinical implications will be discussed further below (see “General Discussion”).

The majority of basic studies examining the effects of extinction on behavior chains found that responding in the initial link decreased more rapidly and to a greater degree than responding in the terminal link. However, Fantino (1965) found that when reinforcement was withheld in a concurrent chain VI-FR schedule, responding in the initial link continued after responding had extinguished in the terminal link. These findings are similar to those found for Bonnie, Timmy, and Sammy (See “General Discussion” for further discussion).

Experiment 3: Effects of Unchaining on the Chain

Procedures

Baseline

Procedures were identical to those conducted in the baseline sessions of Study 1 and 2.

Unchaining

Procedures were identical to those in the baseline sessions with one exception. Reinforcement was delivered contingent on R2 regardless of when it occurred. That is, the child received a small piece of food contingent on completing the chain (i.e., R1, then R2) and contingent on R2 alone. Thus, R2 produced food regardless of whether the box was open. The purpose of this condition was to look at the effects of unchaining R1 (i.e., communicating to open the box) and R2 (i.e., communicating for food) on the level of responding for R1 (i.e., communicating to open the box) and R2. Initially for all

children, the reinforcer (food) for signing “eat” (or “popcorn” for Timmy) outside of the chain “open-eat” was placed behind the therapist’s back, so that the therapist could deliver the reinforcer without opening the box. For Don, beginning with session 16 during the first unchaining phase and with session 42 during the second unchaining phase, the reinforcer was placed on a plate on the table in front of him, next to the box containing additional reinforcers. The reinforcer on the plate was provided contingent on occurrences of the “eat” response outside of the context of the chain (i.e., without the initial “open” response), and the reinforcer in the box was provided contingent on the chain “open-eat”. This modification was made following multiple unchaining sessions during which “eat” responses failed to occur outside of the chain. The purpose was to determine if the presence of the food (the S^D for “eat” in the chain) would set the occasion for “eat” responses outside of the chain.

Results and Discussion

Independent “open” and “eat” or “popcorn” responses during the unchaining evaluation are depicted in the top, middle, and bottom panels of Figure 5 for Bonnie, Timmy, and Don, respectively. The average percentage of inappropriate communication responses for the last three sessions of each condition are depicted in Table 1. Bonnie and Don engaged in low levels of inappropriate “eat” and “open” responses during both baseline phases, indicating that the responses functioned as members of the chain prior to introducing the unchaining procedure. Timmy engaged in no inappropriate “open” responses but moderate levels of inappropriate “popcorn” responses during baseline ($M = 27\%$; see further discussion below). All participants engaged in low levels of inappropriate “open” responses and high levels of inappropriate “eat” or “popcorn”

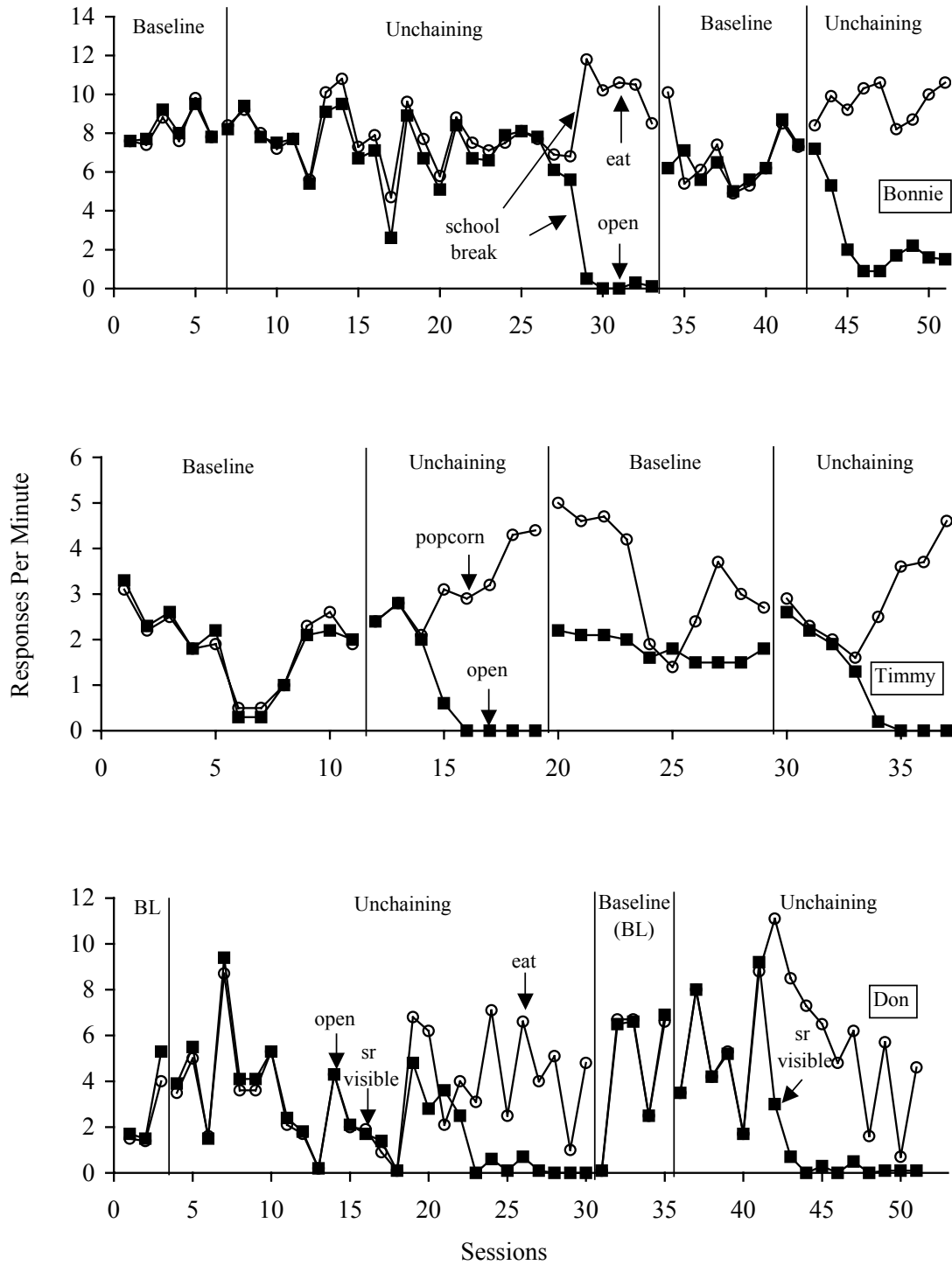


Figure 5. Responses per minute of “open” and “eat” or “popcorn” responses during the unchaining evaluation for Bonnie (top panel), Timmy (middle panel), and Don (bottom panel). “Open” responses are depicted by the filled squares and “eat” or “popcorn” responses are depicted by the open circles.

responses during the unchaining phase. It was expected that a high proportion of “eat” or “popcorn” responses would occur outside of the chain during the unchaining procedure because these responses produced reinforcement.

Both responses were high and stable during the initial baseline phase for Bonnie. Inappropriate “eat” responses averaged 2.8% of the total “eat” responses during the last three sessions of the first baseline phase. With the introduction of unchaining, responding remained high and stable for 22 sessions. At this time (between session 28 and 29), Bonnie’s school had a 3-week break, and sessions were not conducted. Following the break, sessions were resumed. “Open” responses decreased to near zero levels while “eat” responses increased. Thus, responding was almost exclusively allocated to “eat” responses outside of the context of the chain (i.e., to inappropriate “eat” responses) when either the chain “open”-“eat” or “eat” alone resulted in reinforcement. However, this occurred following many sessions and a school break. The average percentage of inappropriate “eat” responses during the last three sessions of the first unchaining phase was 98.7%. During the return to baseline, both responses returned to levels that were similar to those in the initial baseline phase. No inappropriate “eat” responses occurred during the last three sessions of the second baseline. During the second unchaining phase, “open” and “eat” responses occurred at a similar rate for one session. “Open” responses immediately decreased over the next two sessions of the phase and then maintained at a low level across the remainder of the phase. The average percentage of inappropriate “eat” responses was 83.3% during the last three sessions of the second unchaining phase. The higher percentage of inappropriate “eat” responses indicates that Bonnie was engaging in the “eat” response outside of the chain “open-eat”.

Overall, results of the unchaining evaluation for Bonnie indicated that providing the terminal reinforcer for R2, regardless of whether it was preceded by R1, resulted in an overall decrease in R1 (“open”), while R2 (“eat”) occurred frequently outside of the chain. This effect was more immediate during the second exposure to the unchaining contingencies than during the initial unchaining phase.

Rates of “open” and “popcorn” were variable during the initial baseline phase for Timmy. The average percentage of inappropriate “popcorn” responses across the last three sessions of the first baseline phase was 8.1%. With the introduction of unchaining, “open” and “popcorn” responses remained stable for three sessions. “Open” responses then immediately decreased to zero by the 5th session while “popcorn” responses began to increase. The average percentage of inappropriate “popcorn” responses during the last three sessions of the initial unchaining phase was 100%. “Open” responses increased immediately during the return to baseline and remained stable. Throughout baseline, Timmy continued to display moderate levels of inappropriate “popcorn” responses, which had been reinforced during the unchaining phase. This accounts for the higher levels of “popcorn” responses relative to “open” responses during this phase. However, the percentage of inappropriate “popcorn” responses decreased across the phase (from an average of 55.9% during the first three sessions [sessions 20-22] to an average of 27.2% during the last three sessions [sessions 27-29]). As described above, Timmy also engaged in a high level of inappropriate “popcorn” responses during the first baseline phase of Study 2 (extinction), which was conducted *after* he participated in the unchaining study. During Study 2, retraining sessions were conducted with Timmy to decrease the level of “popcorn” responses that occurred outside of the behavior chain

prior to introducing extinction (see description above). However, a similar strategy was not employed to further decrease the level of inappropriate “popcorn” responses during the second baseline phase of the unchaining study. This decision was made because (a) the majority of “popcorn” responses (more than 70%) were occurring within the context of the chain by the eighth baseline session, and (b) the occurrence of inappropriate “popcorn” responses ensured that Timmy's behavior would come into contact with the contingencies that were reintroduced during the second unchaining phase (i.e., reinforcement for signing “popcorn” outside of the chain “open-popcorn”). When unchaining was reintroduced, both responses showed a decreasing trend for the first four sessions after which “popcorn” responses increased and “open” responses decreased to zero fairly rapidly. High levels of inappropriate “popcorn” responses were observed during the last three sessions of the unchaining phases, as expected ($M = 96.6\%$). Overall, results of the evaluation for Timmy indicated that unchaining resulted in a rapid increase in “popcorn” occurring outside of the chain along with a simultaneous decrease in “open” responses.

Following a brief, initial baseline with moderate rates of responding (and no occurrences of inappropriate “eat” responses), unchaining was introduced for Don. Across the first 15 sessions, responding was variable but did not change relative to baseline. That is, Don continued to engage in the chain “open-eat” exclusively although reinforcement was available for “eat” alone. During the 16th unchaining session, the food reinforcer that was available for “eat” outside of the context of the chain was made visible by placing it on the table (it also continued to be placed in the box). Immediately following this manipulation, both responses decreased across several sessions. The rate

of “eat” then increased and maintained at levels similar to those in baseline while “open” decreased and rarely occurred across the final 8 sessions. Inappropriate “eat” responses averaged 99.3% during the last 3 sessions of the first unchaining phase. Both responses rapidly returned to similar levels during the second baseline condition. As with the first baseline, no inappropriate “eat” responses (i.e., those that occurred outside of the chain) were observed before unchaining was again introduced. No changes in responding were observed for either response during the first five sessions. During the sixth session of the reversal to unchaining, the food reinforcer was again placed on the table (as well as in the box). “Open” responses began to decrease to near zero levels immediately following this manipulation. “Eat” responses remained variable and appeared to be on a slight downward trend toward the end of phase. Inappropriate “eat” responses averaged 93.9% during the last 3 sessions of the second unchaining phase. Overall, results of the unchaining evaluation for Don indicated that providing the terminal reinforcer for R2, regardless of whether it was preceded by R1, resulted in a decrease in R1 (“open”) only after the terminal reinforcer was visible. However, R1 may have eventually decreased in the absence of food visibility if Don had received extended exposure to the unchaining procedure.

To summarize, unchaining resulted in a decrease in R1 (“open”) to zero or near zero levels for the three children who participated in this study. However, these changes occurred slowly and across extended sessions for two of the participants. Although Timmy allocated his responding exclusively to “popcorn” following 3 to 4 unchaining sessions, Bonnie continued to exhibit the chain for an extended number of sessions and did not switch over to exclusively signing “eat” until a three-week school break

postponed sessions. During the reversal to unchaining, she immediately began to allocate responding to “eat;” however, low levels of “open” were observed throughout this phase. So, throughout the phase, she continued to engage in the chain “open-eat” even though she frequently contacted reinforcement for “eat” alone. Don engaged in rates of “open” and “eat” that were similar to those observed in baseline across multiple unchaining sessions. In fact, differences in responding were not observed until the reinforcer that was available for “eat” alone was placed in front of him (i.e., until the S^D for “eat” was present).

It is possible that the level of inappropriate “eat” or “popcorn” responses that were occurring immediately prior to the unchaining manipulation influenced the rapidity of the effects on the response chain. Overall, Timmy switched from appropriate to inappropriate “popcorn” responses more quickly than the other participants during the unchaining phase. Timmy also engaged in the highest level of inappropriate “popcorn” responses during baseline. Don did not engage in any inappropriate “eat” responses during the last three sessions of either baseline and his responding was the most resistant to change during the unchaining evaluation. On the other hand, Bonnie’s behavior changed rapidly during the second unchaining phase even though no inappropriate “eat” responses occurred during the last three sessions of the second baseline. Overall, the data indicate a potential relation between the level of inappropriate “eat” or “popcorn” prior to unchaining and the effects on the chain during unchaining. These results will be discussed in greater detail below (see “General Discussion”).

Results of the unchaining evaluation have at least one important applied implication. If a chain of behaviors is established and the reinforcement contingencies

somehow change, the other responses in the chain will be affected also. This could be especially important for individuals with developmental disabilities who have acquired complex skills that are made up of single behaviors linked together in a chain. Results of the current study indicate that if reinforcement was provided for responses that occurred outside of the behavior chain, other responses might decrease. Suppose, for example, a child was taught to raise his hand (R1) and speak (R2) in a classroom, where the contingencies were arranged so that reinforcement was received upon completion of the correct sequence of responses (R1-R2). The first response in the chain (hand raise) might decrease if the contingencies were altered so that reinforcement was delivered for either: a) completing the final step (speaking) alone, or b) completing the entire chain (raising hand–speaking).

Results of the unchaining evaluation also have some conceptual implications. Specifically, results appear to be consistent with the generalized matching law. The matching law states that organisms will distribute their behavior among concurrently available responses in the same proportion that reinforcers are distributed among those alternatives (Hernstein, 1961). In the unchaining evaluation, the participants had two choices: a) Engage in an established sequence of two behaviors to receive reinforcement, or b) engage in a single behavior to receive reinforcement (both on an FR1 schedule). The matching law predicts that the participants would opt for the alternative that results in the greatest proportion of reinforcement (i.e., engaging in the single behavior to gain access to reinforcement). Results are discussed in more detail below (see “General Discussion”).

GENERAL DISCUSSION

General Summary

The effects of three procedures (satiation, extinction, and unchaining) on a two-response behavior chain were evaluated. The procedures directly influenced the relation between the terminal response and the terminal reinforcer by (a) altering the EO linked to the reinforcer (satiation), (b) withholding the terminal reinforcer (extinction), or (c) introducing an additional contingency for the terminal response (unchaining). All procedures resulted in substantial decreases in either one (unchaining) or both (satiation, extinction) members of the chain, with the exception of satiation for Bonnie.

Under satiation and extinction, one member of the chain decreased more rapidly or completely than the other member for several participants. In all of these cases, R1 ("open") was always more persistent than R2 ("eat"). The contingencies associated with the unchaining manipulation also influenced R1 ("open"), but these effects were generally more gradual than those associated with the other procedures. Finally, in a number of cases, a comparison of response patterns during the first versus second exposure to the procedure suggested the possible occurrence of sequence effects. That is, prior exposure to the procedure appeared to increase the sensitivity of the response chain to the manipulation.

As discussed in more detail below, these findings are important for several reasons. First, if appropriate behaviors are shaped in a chain and the contingencies at the end of the chain are then somehow altered, behaviors at the beginning of a chain may be inadvertently influenced. Second, if problem behavior occurs in a chain with appropriate behaviors, efforts to reduce the problem behavior may also reduce appropriate behaviors.

Third, it is important to understand factors that may influence chains consisting of multiple problem behaviors. This may aid in treatment development and selection. Finally, examining factors that affect chains may provide more information about basic processes that have been widely discussed but rarely studied.

Further description of the results, clinical implications, basic findings, limitations, and future directions will be discussed separately for each experiment below.

Experiment 1: Effects of Satiation on the Chain

Summary of Results

Based on the results of basic studies, it was expected that R1 (“open”) and R2 (“eat”) would decrease during the satiation evaluation (Michael, 2000). Establishing operations that influence the reinforcing effectiveness of food most likely would influence the reinforcing effectiveness of other stimuli that are uniquely paired with food (i.e., conditioned reinforcers). The consequence for the “open” response (i.e., box open/food visible) was likely a conditioned reinforcer due to pairing with food delivery. Therefore, manipulations that decrease the effectiveness of the reinforcer following R2 (“eat”) would not only influence R2, but R1 (“open”) as well.

Results indicated that R1 and R2 decreased for 3 of 4 children. No reductions were observed for Bonnie. During the satiation assessment, Bonnie continued to consume food up to the 30 min maximum time allotted, suggesting that this amount or duration of food access was not sufficient to alter the effectiveness of food as a reinforcer. Don also continued to consume the reinforcer up to the 30 min maximum time during the satiation assessment. However, it was noted anecdotally that Don’s consumption slowed down and ceased briefly (i.e., less than 5 min) during the later part

of the satiation assessment. These differences in anecdotal information for Bonnie and Don are consistent with results. That is, 30 min free access to the terminal reinforcer had a larger influence on Don's behavior than on Bonnie's behavior. For Leroy and Sammy, a more immediate decrease was observed for R2 (“eat”) than for R1 (“open”). After the first few satiation sessions, R1 and R2 occurred at similar levels for Leroy and to some extent for Sammy (second phase only). For Don, both “open” (R1) and “eat” (R2) decreased simultaneously following the satiation period.

Laboratory Findings and Basic Relations

As discussed earlier, the majority of basic studies examining the effects of satiation on responding under chain schedules found that behavior in the initial link (R1) decreased more rapidly than behavior in the terminal link (R2) (Fischer & Fantino, 1968; Malott, 1966; Mandell, 1980). Fischer and Fantino (1968) examined the effects of satiation on responding under a two-component chain schedule. During satiation, responding initially decreased in the initial link while maintaining in the terminal link, but the reductions were similar in both links after approximately four sessions. The authors’ evaluation of the results indicated that response rates decreased as a function of the number of prefeeding sessions conducted. That is, responding decreased as the overall number of prefeeding sessions increased. Although responding in the terminal link (R2) was disrupted more quickly than responding in the initial link (R1) for two participants in the current study (inconsistent with basic findings), this outcome was not obtained during the second satiation phase. That is, consistent with the results of Fischer and Fantino (1968), the responses decreased simultaneously with continued exposure to

the satiation procedure. This may help explain the differences in reduction during sessions in the first satiation phase versus those in the second satiation phase.

Furthermore, in at least one study on satiation (Morgan et al., 1977), rats continued to perform the initial steps in a behavior chain after they had stopped responding during the later links in the chain (and stopped consuming the reinforcer). The rats were required to enter an alley, remove an obstructing ball, and run down an alleyway to a food cup to obtain food reinforcement. During satiation, the rats had free access to food for 1 hour prior to each session. Mean running speeds declined most rapidly in the terminal link, followed by the middle link, and then the initial link. These results are similar to those in the current study.

Responding may be more persistent in the initial link than in the terminal link due to the effects of conditioned reinforcement (Fantino & Logan, 1979). In the current study, R1 (“open”) resulted in a change in the stimulus condition (box open/food visible). In the presence of box open/food visible, R2 (“eat”) resulted in reinforcement. Box open/food visible likely functioned as a conditioned reinforcer for R1, although this function was not directly evaluated. The association between the terminal link response (R2) and the reinforcer was more direct and, thus, may have been more easily disrupted with changes in establishing operations.

Applied Implications

There are at least two applied implications that can be drawn from the satiation evaluation. As mentioned earlier, the results have implications for the use of NCR as an intervention for problem behavior. NCR interventions designed to target problem behavior that occurs at the end of a behavior chain may result in concomitant decreases in

behaviors that occur earlier in the chain. This could be advantageous if the other behaviors are maladaptive. For example, a child may grab someone's shirt and then bite the person to escape from work. This chain consists of two maladaptive behaviors (i.e., grabbing and biting). Efforts to reduce the second behavior in chain (biting), such as noncontingent escape, may also reduce the first behavior in the chain (grabbing). Situations may also exist where appropriate behavior occurs prior to problem behavior in a behavior chain and efforts to reduce the problem behavior may also reduce the earlier, appropriate behavior. For example, a child may say, "play" and then hit a caregiver to get attention. This chain consists of an appropriate behavior (saying, "play") and an inappropriate behavior (hitting). Efforts to reduce hitting (R2) through the use of noncontingent attention may result in concomitant decreases in the appropriate behavior "play" (R1).

Results from the satiation evaluation also have implications for unintentionally reducing multiple behaviors when an environmental change results in a satiation effect. This could happen when the delivery of any reinforcer responsible for maintaining a chain of behaviors (e.g., food, toys) is provided on a schedule that is too dense. For example, contingencies in a classroom or workshop setting may possibly be arranged such that reinforcers are provided contingent on completing chains of behavior (e.g., vocational tasks, self-care tasks). If the reinforcers for completing the behaviors chains also become available noncontingently throughout the day, multiple responses may decrease.

Limitations

This study has several limitations. First, using food as reinforcement necessarily limited the amount of the reinforcer that could be provided during the pre-session access period. This may have restricted the extent to which the satiation manipulation could be evaluated. In addition, results may not necessarily extend to other types of reinforcers, such as attention from others and highly preferred activities. An additional weakness is that, for two participants, the length of phases and level or variability in responding limited the interpretation of the results. For Leroy, all of the phases during the satiation evaluation were fairly short. The longest phase was the first satiation phase, which was seven sessions. During the first two sessions of the second baseline phase, responding was low and consistent with the level of responding in several satiation sessions. High levels of responding were observed during the following sessions, but only two additional baseline sessions were conducted. In addition, the second satiation phase was brief (four sessions). For Don, responding was variable during baseline and response rates in several sessions were similar to those observed during satiation sessions. Nevertheless, reductions in behavior and trends observed across phases support the interpretation of the results.

Future Directions

The basic relation between satiation and response chains should be evaluated further with other reinforcers, such as toys and attention, to increase the generality of the findings (e.g., to NCR procedures using toys as reinforcers). An additional avenue for future research might involve investigating potential factors responsible for the discrepancies between the findings of the current study and past studies. For two

participants in the current study, R2 decreased more quickly than R1. Previous basic investigations on chain schedules found that responding decreased more quickly in the initial link (R1) than in the terminal link (R2) (e.g., Malott, 1966; Mandell, 1980). Explanations for both findings have been described in the basic literature as follows: a) responses further away from the terminal reinforcer are more easily disrupted due to the temporal delay between the response and the reinforcer, and b) initial-link responses are more persistent than terminal-link responses due to the effects of conditioned reinforcement. In future studies, factors suspected to influence the pattern of interruption should be directly manipulated (e.g., length of exposure to the satiation manipulation, number of pairings between conditioned reinforcer and primary reinforcer). Finally, the possibility that satiation influences behavior chains differently than responding under chain schedules should be explored.

Experiment 2: Effects of Extinction on the Chain

Summary of Results

During the extinction evaluation, it was expected that “eat” (R2) would decrease because the response-reinforcer relationship was disrupted and that “open” (R1) also would decrease because the open box was no longer paired with food delivery (Michael, 2000). Decreases in responding were observed in both R2 (“eat”) and R1 (“open”) for all four participants who participated in this study. For three of the four children, R2 decreased to a lower level more rapidly than R1.

Laboratory Findings and Basic Relations

The differential effects of extinction on R1 and R2 are inconsistent with the majority of basic studies in this area, which have found that initial-link responding

decreased more rapidly and to a greater degree than responding in the terminal link. As noted above, responses in the early part of a chain are expected to be more easily disrupted because they are further from the terminal reinforcer (Mazur, 2002).

However, some basic research supports the findings in the current study. For example, Fantino (1965) found that responding on a concurrent chain VI-FR schedule decreased more quickly in the terminal link than in the initial link during extinction. In this study, pigeons could respond on one of two keys on a VI schedule. When the schedule in the initial link was met, a light illuminated and the pigeons were required to respond on an FR schedule to access reinforcement. During extinction, the food tray did not operate. Results were similar to those obtained in the current investigation. Fantino (1965) hypothesized that, during extinction, the stimulus correlated with the terminal link functioned as a conditioned reinforcer for responding in the initial link, but no longer functioned as a discriminative stimulus for responding in the terminal link.

Moreover, in Fischer (1967), subjects exposed to a greater number of sessions with access to larger amounts of food during baseline (reinforcement) stopped responding more quickly during the second link of a two-link chain schedule during extinction. Conversely, responding decreased more quickly in the early links of the chain for subjects who participated in fewer previous sessions and with smaller amounts of reinforcement. Although the amount of exposure to reinforcement prior to extinction was not controlled in the current study, this factor may help explain the findings. Each child's exposure to the reinforcement contingencies for engaging in the chain varied, given that several of them participated in the other studies (i.e., satiation or unchaining) prior to the extinction evaluation, and the number of training sessions in the current study varied.

Extinction was the first study for Bonnie and Don, who had 22 and 9 combined training and baseline sessions prior to extinction, respectively. Extinction was the second study for Timmy and Sammy, and they had 78 and 87 combined training and baseline sessions prior to extinction, respectively. Thus, Don had substantially less exposure to reinforcement prior to extinction than the other participants. Overall, both of Don's responses decreased simultaneously during extinction. For the other three children, R2 ("eat") decreased more rapidly than R1 ("open") during extinction. These findings are consistent with those of Fischer (1967).

Applied Implications

The results also have important applied implications. Extinction might occur in naturalistic settings when the terminal response in a behavior chain cannot be reinforced (e.g., a caregiver runs out of reinforcers, the caregiver is occupied with another activity) or when reinforcement is deliberately withheld (e.g., the response is occurring too frequently or it is inappropriate). Regardless, responding in the later links would be expected to decrease, but other responses in the chain would also likely decrease. In addition, extinction is a commonly used treatment for problem behavior. If problem behavior is linked in a chain with other problem or appropriate behaviors, these behaviors will likely be influenced when extinction is implemented for the target behavior.

Limitations

There are a few limitations of the current study. First, Sammy's extinction sessions were terminated before responding had completely extinguished due to his discharge from the inpatient unit. It would have been preferable to conduct additional sessions. In addition, variable and unstable responding was observed in some baseline

phases, limiting the experimental rigor of the study. Specifically, Don's responding showed an upward trend during the initial baseline and a slight downward trend during the second baseline. Responding during Sammy's second baseline phase was quite variable, decreasing to zero or near zero levels three times. Results of Timmy's first baseline phase indicated that a three-response chain ("popcorn-open-popcorn") was inadvertently established. Following retraining, a brief number of sessions were conducted prior to introducing extinction. In addition, Timmy's second baseline phase during the extinction evaluation was relatively brief (i.e., four sessions). Nonetheless, overall trends and levels of responding during baseline and extinction support the conclusions discussed above.

Future Directions

There are several additional avenues for future research on the effects of extinction on behavior chains. Previous research findings on the effects of extinction in behavior chains have been mixed. Factors that have been hypothesized to have an effect on which response in the chain decreases more quickly with extinction (i.e., R1, R2, or R1 and R2 simultaneously) could be manipulated in future studies. This could include the length of exposure to the reinforcement contingencies prior to extinction, the number of responses in the chain, and the schedule of reinforcement prior to extinction.

In addition, the effects of exposing R1 to extinction on the other members of the chain could be examined. In this case, for example, "open" (R1) would no longer result in box open/food visible, but "eat" would continue to result in reinforcement. Finally, extinction is not always possible depending on the nature of the behavior (e.g., attention-maintained aggression towards other children). In such cases, the response chain may be

maintained on thin schedules of reinforcement. Therefore, it might be interesting to examine the effects of thinning the schedule of reinforcement for responding in a chain.

Previously, only one applied study has examined the effects of extinction on behavior chains (Horner, Wuerch, & Boomer, 1981). Participants performed more slowly during extinction, but responding did not completely extinguish for any participant. The effects of extinction on behavior chains in applied settings should be examined further. In addition, because extinction is often used as a treatment for undesirable behaviors, undesirable behaviors that occur as part of chain with appropriate behavior should be examined in future research in order to study the effects of extinction on appropriate behavior.

Experiment 3: Effects of Unchaining on the Chain

Summary of Results

It was expected that R1 (“open”) would decrease because the open box was no longer differentially paired with food even though it continued to be reinforced (Michael 2000). Results indicated that unchaining resulted in decreases in R1 for all children. For two of the children, changes in responding were somewhat gradual during at least one unchaining phase (Bonnie and Don).

Laboratory Findings and Basic Relations

Although no previous basic studies on “unchaining” could be identified, Nevin et al. (1981) arranged for an alternative response to access reinforcement concurrently with a chain schedule. In the study, pigeons always switched to the single, alternative response immediately when it was available rather than engage in the chain of responses to access the same reinforcement. The findings in the current study were similar, in that

all of the participants switched from engaging in the chain “open-eat” (R1-R2) to “eat” (R2) alone when both produced the same reinforcement. However, in some cases, responding shifted to R2 alone in a relatively gradual manner. For both Bonnie and Don, a decrease in “open” only occurred following multiple sessions with unchaining and a break in sessions (Bonnie) or an additional manipulation (the reinforcer was made visible for Don). Interestingly, changes in responding rapidly occurred during the second unchaining phase for Bonnie, indicating that prior exposure to the unchaining manipulation influenced behavioral sensitivity to this contingency.

Several important differences between the Nevin et al. (1981) study and the current study may account for the differences in these findings. One possible reason is that the alternative response in the Nevin et al. (1981) study was pecking on a different key (i.e., exclusive from the keys in the chain), which illuminated when reinforcement was available for that response. In the current study, a member of the response chain (R2) rather than a separate, alternative behavior produced reinforcement, and the introduction of the new contingency was not correlated with any specific environmental change that would signal the availability of reinforcement for the terminal response (R2) alone. In fact, Don's “open” responses rapidly decreased when this type of stimulus change was introduced.

Applied Implications

Results are also important from an applied perspective. Food reinforcers are often used to establish and maintain chains of appropriate behaviors in individuals with developmental disabilities. If a caregiver begins to reinforce a single, later response in a chain as well as the entire chain, earlier appropriate behavior could be eliminated. For

example, in a vocational setting, an instructor may require workers to engage in a chain of responses (e.g., pick up paper, place paper in shredder, empty shredder) to receive reinforcement and then may eventually alter the contingency so that reinforcement is available for completing the entire chain or just the last step (e.g., empty shredder).

Limitations

This study is limited in several respects. First, an unplanned break occurred during the first phase of unchaining with Bonnie. Response patterns are consistent with the conclusion that the break influenced the results (i.e., “open” had maintained prior to the break but rapidly decreased when sessions resumed); thus, it is unknown how responding would have differed in the absence of the break. Second, the reinforcer that was available for the “eat” response outside of the chain “open-eat” was made visible (i.e., placed on the table) prior to observing changes in responding for Don. This manipulation was introduced because few inappropriate “eat” responses had occurred -- and, thus, few had contacted reinforcement -- after multiple sessions with unchaining. This manipulation probably led to an increase in inappropriate “eat” responses and the resulting decrease in “open” responses because the visibility of the food functioned as an S^D for “eat”. It remains unknown if these responses would have changed without the additional manipulation.

In addition, several factors that could have influenced the effects of unchaining were not held constant across participants. For example, differences in the pattern of disruption observed across the three participants could possibly be attributed to different amounts of exposure to reinforcement prior to unchaining or to the different level of inappropriate “eat” responses during baseline. For example, Timmy engaged in a

moderate level of inappropriate “eat” responses during the last three sessions of each baseline phase, whereas the other two participants engaged in much lower levels of inappropriate “eat” responses. It is possible that the level of responding outside of the context of the chain during baseline may have affected levels of responding during unchaining. A final limitation is that the initial baseline phases for Bonnie and Don were fairly brief.

Future Directions

The effects on responding in an established chain when reinforcement is made available for a response outside of the chain should be investigated in future studies. This manipulation would be relevant to FCT, a widely used intervention for problem behavior exhibited by individuals with developmental disabilities. With FCT, the reinforcer responsible for maintaining problem behavior is used to shape and maintain an alternative response (e.g., handing a picture card to a caregiver). If problem behavior occurred as part of a chain prior to FCT, other responses in the chain might decrease during treatment. This arrangement, which would resemble that evaluated by Nevin et al. (1981), may lead to a reduction in multiple members of the response chain.

The effects of the response effort for the alternative response also could be manipulated in future research. Differences in response effort might affect whether individuals switch from a chain of responses to a single response. For example, a child could be presented with one of two concurrent response-reinforcement arrangements: a) complete a chain of several easy math problems to receive reinforcement, or complete one difficult math problem to receive the same amount of reinforcement, versus b) complete a chain of several easy math problems to receive reinforcement or one easy

math problem to receive the same amount of reinforcement. In this way, the amount of responding allocated to the single easy math problem could be compared to the amount of responding allocated to the single difficult math problem. The child may be less likely to switch from the chain to the single alternative response when the alternative is a difficult problem.

As mentioned earlier, results of the current study are consistent with the generalized matching law. Based on the matching law, it is expected that participants will distribute their behavior among concurrently available responses in the same proportion that reinforcers are distributed among those alternatives (Hernstein, 1961). In the current study, the participants engaged in a single behavior when it resulted in the same reinforcement as a chain of two behaviors. Additional relevant variables should be manipulated in future studies to address the applicability of the matching law to the procedures and response chain used in the current study. Such variables could include the schedule of reinforcement (e.g., an intermittent schedule for single responses versus a continuous schedule for response chains) or the amount of reinforcement delivered (e.g., more reinforcement for the response chain than for the single response).

General Conclusions

Applied research on procedures that may disrupt behavior chains is limited to a handful of studies. This is a significant area of study, given that much of human behavior occurs in the context of behavior chains. An important next step in conducting further applied research on behavior chains is to develop a methodology for identifying previously established response chains. Several applied studies have been conducted based on the hypothesis that problem behavior occurred as part of a behavior chain (e.g.,

Fisher, Lindauer, Alterson, & Thompson, 1998; Kohlenberg, 1970; Zlutnick, Mayville, & Moffat, 1975). However, these studies were based on anecdotal observation that the behaviors of interest occurred in chains.

In a recent study, the authors hypothesized that an individual's self-injury occurred as the second response in a two-response chain consisting of stereotypy and eye-poking (Hagopian, Paclawskyj, & Kuhn, in press). To further explore this possibility, the conditional probability of self-injury given the occurrence of stereotypy was determined. In addition, within-session response patterns were examined by inspecting cumulative occurrences of stereotypy and self-injury. Both analyses indicated that eye poking was more likely to occur following stereotypy. In addition, a treatment that targeted stereotypy was effective in reducing both stereotypy and self-injury. This study demonstrates a preliminary method for determining if responses targeted for intervention occur as part of a behavior chain. Further research is needed in this area.

Although the behavior chains examined in the current study were somewhat artificial, the communication responses taught to the participants were clinically relevant and useful in their daily lives. Furthermore, anecdotal information indicates that the children benefited from participating in this study in several ways. For example, Sammy engaged in problem behavior (e.g., out of seat, aggression, crying) on his living unit to escape work tasks. During the two studies in which Sammy participated, sitting at a table and engaging in appropriate behaviors were reinforced across numerous sessions. Over the course of the investigation, Sammy began walking over to the table, sitting in his chair, and pulling his chair up to the table independently (behaviors which he did not previously display).

Prior to the study, it was reported that sign training had been attempted in Bonnie's classroom and in speech therapy but had been unsuccessful. Likewise, sign training had been attempted with Don during speech therapy with minimal success. Sammy had no prior exposure to sign training. Over the course of this study, caregivers, direct care staff, or teachers reported increases in signing outside of study sessions for these participants. All three children reportedly engaged in the "eat" response to request food outside of sessions although none were reported to engage in "open" outside of sessions. Don and Bonnie also acquired additional responses (e.g., please, finished, bathroom). One limitation is that the consequences (e.g., reinforcement) for engaging in "eat" outside of study sessions and the effects of these consequences on the results are unknown. However, this outcome also should be viewed as a potential strength. Generalization of new behaviors to novel settings and caregivers is a major challenge facing practitioners and researchers. In the current study, the behavior of three children apparently generalized to other settings and caregivers in the absence of explicit programming.

In addition to the avenues for future research discussed above, a number of other relevant research questions remain. First, the effects of these procedures on lengthier response chains should be evaluated in further studies. Second, responses that occur within the context of multiple behavior chains could be examined in future studies. In this case, disrupting one of the chains may alter responding in other chains. Third, the effects of intermittently reinforcing behaviors that occur as part of chains could be examined in settings such as workshops and schools. Fourth, treatments for problem behavior that occur within the context of chains should be examined in future studies.

For example, the effectiveness of withholding the terminal reinforcer versus targeting behaviors earlier in the chain could be evaluated. Fifth, strategies that would enable caregivers to maintain appropriate behaviors while targeting inappropriate behaviors that occur together in a behavior chain could be examined. Finally, the possibility of sequence effects should be evaluated more closely in future investigations. In particular, future studies should determine if prior experience with extinction, satiation, or unchaining procedures increases the sensitivity of responding to these manipulations.

REFERENCES

- Catania, A. C. (1998). *Learning*. Upper Saddle River, NJ: Prentice Hall.
- Caitlin, J. & Gleitman, H. (1973). Pattern of disruption in the extinction of a chain FR 7 – FR 7 in pigeons. *Animal Learning and Behavior*, 1(2), 154-156.
- Cooper, J. O., Heron, T. E., & Heward, W. L. (1987). *Applied Behavior Analysis*. Upper Saddle River, NJ: Prentice Hall.
- Duker, P., Kraaykamp, M., & Visser, E. (1994). A stimulus control procedure to increase requesting with individuals who are severely/profoundly intellectually disabled. *Journal of Intellectual Disability Research*, 38, 177-186.
- Fantino, E. (1965). Some data on the discriminative stimulus hypothesis of secondary reinforcement. *The Psychological Record*, 15, 409-415.
- Fantino, E. & Logan, C. A. (1979). *The Experimental Analysis of Behavior*. San Francisco: W. H. Freeman and Company.
- Ferster, C. B. & Skinner, B. F. (1957). *Schedules of Reinforcement*. New York: Appleton-Century-Crofts.
- Findley, J. P. (1962). An experimental outline for building and exploring multi-operant behavior repertoire. *Journal of the Experimental Analysis of Behavior*, 5, 113-166.
- Fischer, K. W. (1967). The effect of degree and type of training upon extinction of a response chain in pigeons. *Psychonomic Science*, 9, 430-404.
- Fischer, K. & Fantino, E. (1968). The dissociation of discriminative and conditioned reinforcing functions of stimuli with changes in deprivation. *Journal of the Experimental Analysis of Behavior*, 11, 708-710.
- Fisher, W., Piazza, C., Cataldo, M., Harrell, R., Jefferson, G., & Conner, R. (1993). Functional communication training with and without extinction and punishment. *Journal of Applied Behavior Analysis*, 26, 23-36.
- Fisher, W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, J. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis*, 25, 491-498.

- Fisher, W. W., Lindauer, S. E., Alterson, C. J., & Thompson, R. H. (1998). Assessment and treatment of destructive behavior maintained by stereotypic object manipulation. *Journal of Applied Behavior Analysis*, 31, 513-527.
- Gollub, L. R. (1977). Conditioned reinforcement: Schedule effects. In W. K. Honig & J. E. R. Staddon (Eds.), *Handbook of Operant Behavior*. Englewood Cliffs, NJ: Prentice Hall.
- Hagopian, L. P., Farrell, D. A., & Amari, A. (1996). Treating total liquid refusal with backward chaining and fading. *Journal of Applied Behavior Analysis*, 29, 573-575.
- Hagopian, L. P., Paclawskyj, T. R., & Kuhn, Stephanie A. C. (in press). The use of conditional probability analysis to identify a response chain leading to the occurrence of eye poking. *Research in Developmental Disabilities*.
- Hall, G. & Sundberg, M. L. (1987). Teaching mands by manipulating conditioned establishing operations. *The Analysis of Verbal Behavior*, 5, 41-53.
- Hernstein, R. J. (1961). Relative and absolute strength of response as a function of frequency of reinforcement. *Journal of Experimental Analysis of Behavior*, 4, 563-573.
- Horner, R. H., Wuerch, B.B., & Boomer, J. D. (1981). Performance of three severely mentally retarded adults on vocational response chains during extinction. *American Journal of Mental Deficiency*, 86(1), 97-103.
- Kazdin, A. E. (2001). *Behavior modification in applied settings* (6th ed.). Thomson Learning, CT: Stamford.
- Kelleher, R. T. & Fry, W. (1962). Stimulus functions in chained fixed-interval schedules. *Journal of the Experimental Analysis of Behavior*, 5, 167-173.
- Kohlenberg, R. J. (1970). The Punishment of Persistent Vomiting: A Case Study. *Journal of Applied Behavior Analysis*, 3, 241-245.
- Lerman, D. C., & Iwata, B. A. (1996). Developing a technology for the use of operant extinction in clinical settings: An examination of basic and applied research. *Journal of Applied Behavior Analysis*, 29, 345-382.
- Leslie, J. S. (1969). Effects of punishment and probability of reinforcement on a two-response chain. *The Irish Journal of Psychology*, 2, 120-130.
- Luyben, P. D., Funk, D. M., Morgan, J. K., Clark, K. A., & Delulio, D. W. (1986). Team sports for the severely retarded: Training a side-of-the-foot soccer pass using a

- maximum-to-minimum prompt reduction strategy. *Journal of Applied Behavior Analysis*, 19, 431-436.
- Malott, R. W. (1966). The effects of prefeeding in plain and chained fixed ratio schedules of reinforcement. *Psychonomic Science*, 4, 285-287.
- Mansfield, R. J. & Rachlin, H. C. (1970). The effect of punishment, extinction, and satiation on response chains. *Learning and Motivation*, 1, 27-35.
- Mandell, C. (1980). Response strength in multiple periodic and aperiodic schedules. *Journal of the Experimental Analysis of Behavior*, 33, 221-241.
- Mazur, J. E. (2002). *Learning and Behavior*. Upper Saddle River, NJ: Prentice Hall.
- McDonnell, J. & McFarland, S. (1988). A Comparison of Forward and Concurrent Chaining Strategies in Teaching Laundromat Skills to Students with Severe Handicaps. *Research in Developmental Disabilities*, 9, 177-194.
- McGill, P. (1999). Establishing operations: Implications for the assessment, treatment, and prevention of problem behavior. *Journal of Applied Behavior Analysis*, 32, 393-418.
- Michael, J. (1987). *Concepts and principles of applied behavior analysis*. Kalamazoo, MI: Association for Behavior Analysis.
- Michael, J. (1993). Establishing operations. *Behavior Analyst*, 16, 191-206.
- Michael, J. (2000). Implications and refinements of the establishing operation concept. *Journal of Applied Behavior Analysis*, 33, 401-410.
- Morgan, M. J., Eison, D., & Morris, R. G. M. (1977). Inhibition and isolation rearing in the rat: Extinction and Satiation. *Physiology & Behavior*, 18, 1-5.
- Nevin, J. A., Mandell, C., & Yarensky, P. (1981). Response rate and resistance to change in chained schedules. *Journal of Experimental Psychology: Animal Behavior Processes*, 7, 278-294.
- Sigafoos, J., Reichle, J., Doss, S., Hall, K., & Pettitt, L. (1990) "Spontaneous" transfer of stimulus control from tact to mand contingencies. *Research in Developmental Disabilities*, 11, 165-176.
- Shirley, M. J., Iwata, B. A., Kahng, S., Mazaleski, J. L., & Lerman, D. C. (1997). Does functional communication training compete with ongoing contingencies of reinforcement? An analysis during response acquisition and maintenance. *Journal of Applied Behavior Analysis*, 30, 93-104.

- Smith, R. G., & Iwata, B. A. (1997). Antecedent influences on behavior disorders. *Journal of Applied Behavior Analysis*, 30, 343-375.
- Spooner, F. (1984). Comparisons of backward chaining and total task presentation in training severely handicapped persons. *Education and Training of the Mentally Handicapped*, 19, 15-22.
- Thomas, J. R. (1964). Multiple baseline of stimulus functions in an FR chained schedule. *Journal of the Experimental Analysis of Behavior*, 7, 241-245.
- Wacker, D. P., Steege, M. W., Northup, J., Sasso, G., Berg, W., Reimers, T., Cooper, L., Cigrand, K., & Donn, L. (1990). A component analysis of functional communication training across three topographies of severe behavior problems. *Journal of Applied Behavior Analysis*, 23, 417-429.
- Williams, B. A. (1994). Conditioned reinforcement: Experimental and theoretical issues. *The Behavior Analyst*, 17, 261-285.
- Wilder, D. A., & Carr, J. E. (1998). Recent advances in the modification of establishing operations to reduce aberrant behavior. *Behavioral Interventions*, 13, 43-59.
- Winborn, L., Wacker, D. P., Richman, D. M., Asmus, J., & Geier, D. (2002). Assessment of mand selection for functional communication training packages. *Journal of Applied Behavior Analysis*, 35, 295-298.
- Zlutnick, S., Mayville, W. J., & Moffat, S. (1975). Modification of seizure disorders: The interruption of behavioral chains. *Journal of Applied Behavior Analysis*, 8, 1-12.

VITA

Stephanie Ann Contrucci Kuhn attended Virginia Tech, graduating in 1993. She was employed at Kennedy Krieger Institute for several years before entering graduate school at Louisiana State University under the supervision of Dorothea C. Lerman, PhD. In December 2000, she earned a master's degree from Louisiana State University. She completed her predoctoral internship at the Kennedy Krieger Institute under the supervision of Louis P. Hagopian, Ph.D. Currently, she is a case manager on the Neurobehavioral Unit at the Kennedy Krieger Institute in Baltimore, Maryland. After graduating from Louisiana State University in May, 2004 she anticipates receiving a faculty appointment through her current position at Kennedy Krieger Institute and Johns Hopkins University School of Medicine. Her current research and clinical interests include the treatment of severe behavior problems from a behavior analytic approach.